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LOCOMOTIVE SPARK ARRESTERS.

By J. SNOWDEN BELL.

Read before the Franklin Institute at its meeting, Dec. 17th, 1879.

The spark arrester, although one of the earliest of the numerous improvements which have contributed to the advancement of American locomotive engineering, has, as yet, failed to attain a degree of perfection commensurate with that of many constructive details of later origin. While from its earliest period to the present it has received continued attention, and has probably been the subject of more experiment and inventive effort than any other adjunct of the locomotive, the variations in the present practice, which will be obvious to even an unskilled observer, show clearly that the standard has not yet been arrived at. The boilers, frames, cylinder attachment and valve gearing of different builders have been reduced to uniformity in all substantial particulars, but there is a considerable range of difference in the construction of spark arresters.

As preliminary to a review of the history and present development of locomotive spark arresters it may be remarked, that to constitute a *perfect* one, there would be required a device which would offer no impediment to the draught, and at the same time completely bar the

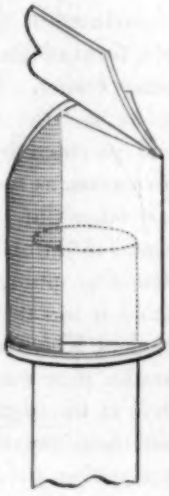
escape of unconsumed fuel from the stack. This has never yet been produced, and so far as the present system of locomotive boilers is concerned, doubtless never will be, the conditions being too directly at variance to render it possible for both of them to be satisfactorily complied with. Comparatively few of the results of the efforts made in this direction have survived the tests of practical operation, and it cannot be said of any of them that it is entirely free from objection, or so nearly adapted to the requirements of successful performance as to either merit or receive general acceptance as an approximately perfect apparatus.

The spark arrester is peculiarly an American institution, and possesses but little practical value beyond that derived from American practice. Nearly twenty years ago a suit was brought against M. W. Baldwin & Co., the Philadelphia locomotive builders, by David Matthew, for infringement of patents granted him for spark arresters, and as a part of their defence, Messrs. Baldwin & Co. prepared a drawing showing 57 different forms of locomotive stacks and spark arresters which had been used or patented prior to 1858. This drawing, which it is believed has never been published, fully exemplifies the state of the art up to and at that time, and although, owing to the fact that the suit was not prosecuted, the dates of the different constructions shown were not authenticated by testimony, it will be found to possess much interest for those who may desire to investigate early practice in this direction.

The late Zerah Colburn, writing in 1860, says that the necessity for spark arresters arose with the introduction of wood burning locomotives in 1830, and it is probable that about that time they were first applied, in the form of a wire netting cap placed over the top of the smoke stack. The earliest record which we have been able to discover is the U. S. patent granted to James P. Espy, of Philadelphia, June 29th, 1833, a description and illustration of which, accompanied by certificates of its successful performance, may be found in the JOURNAL OF THE FRANKLIN INSTITUTE, vol. 12, new series, 1833, pp. 418-421. Espy's "draft generating chimney cap," as he termed it, was designed for steamboats as well as locomotives, and was merely a cap pointed or inclined at its front end and kept to the wind by a vane, in the manner of an ordinary chimney cap; its opening was covered by a sheet of fine wire gauze. Espy's cap is shown in Fig. 1. The specification states that it "affords a very free egress to the gases whilst

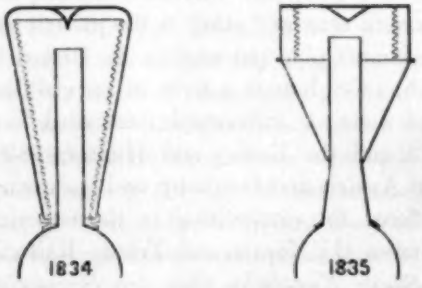
it completely stops the sparks," and the engineer of Mr. Baldwin' locomotive engine (on the Philadelphia and Germantown Railroad) certifies that "with a wire gauze so fine that the head of a pin could not go through the meshes, which was quite too fine, it effectually stopped the sparks without diminishing the draft, and in some cases it even increased it, as by opening the door to put in wood the flame did not come out as it did previously in similar circumstances." Notwithstanding these remarkable statements as to its virtues, which, upon this showing, were certainly very much superior to those of any we now know of, Espy's draft cap had but a brief existence, and is not even honored with a position in the Baldwin drawing before referred to.

Fig. I.



Succeeding Espy's will be found several patented inventions, dating from 1834 to 1836, none of which came into use to any extent nor possess points that have been embodied in later practice. Passing these as merely unsuccessful speculations, we find the elements of the type of spark arresters which has met with most general acceptance in the United States, in the so-called "bonnet pipe," in which an inverted cone, turned downwards at its outer edge and placed over the mouth of the stack, deflected the sparks and cinders into a surrounding casing, while the smoke and gases escaped through a wire

8 Fig. 2. 9



netting or "bonnet," covering the wide top of the outer casing. The invention of the bonnet pipe is claimed by Colburn for Wm. T. James, of New York, in an engine placed by the latter on the Baltimore and

Ohio Railroad in 1833 (*Recent Practice in the Locomotive Engine*, p. 59), but, as exhibited in the Baldwin drawing, dates from 1834, and is to be credited to Isaac Dripps, then master mechanic of the Camden and Amboy Railroad; Nos. 8 and 9 of the drawing, which are here reproduced in Fig. 2, each showing a crude, although not impracticable, form of the combination of the deflector, netting, inside pipe and outer casing. Colburn (*The Engineer*, Philadelphia, 1860, p. 137) refers to "the cone and netting pipe made by Isaac Dripps in 1835, and patented by him in 1837." The latter statement is, however, erroneous, as no spark arrester was patented by Mr. Dripps at that or any other time. Different forms of the bonnet pipe were patented by Duff (1837) and Briscoe (1838), and in *Locomotives and Locomotive Building*, published by the Rogers Locomotive and Machine Works, 1876, it is stated (p. 9), referring to the engine "Sandusky," built by Rogers, Ketchum & Grosvenor, and first run October 6th, 1837: "the smoke pipe was of the bonnet kind, having a deflecting cone curled over at the edges in its centre, so as to deflect the sparks downward, and thus prevent their passing through the wire bonnet, as well as preventing the bonnets wearing out too fast." Numerous unimportant variations of the bonnet pipe succeeded the original examples of Dripps and Rogers, and it reached its latest form, known as the "Yankee" stack, about 1841. As exemplified in the Mason engines of 1857 (Fig. 3), it is still extensively used for wood burning engines, but in bituminous coal burners has given place generally to the modification usually termed the "diamond" stack (Fig. 4), in which the cone and netting are retained and the outer casing reduced in dimensions. The diamond stack, with various modifications of detail, is in use to a greater extent than any other at the present time.

A form of the bonnet pipe patented in the United States by W. T. James, April 13th, 1838, having a series of curved discharge passages under the central deflector (afterwards embodied in the French and Baird stack, 1842, and the Radley and Hunter, 1850), was adopted by constructors in Austria and Germany, and is shown in the drawings of the engines offered for competition in the experiments upon the Semmering incline of the Vienna and Trieste Railway, in 1852 (*Die Lokomotive der Staats Eisenbahn über den Semmering*, Wien, 1854, Bl. XVI, XXI). In European treatises of much later date than the James patent, it will be found described as a German invention, and

is termed "Klein's apparatus" (*appareil de Klein*). It was, moreover, patented in England by one Charles Cowper, in 1851, No. 13,705.

Fig. 3.

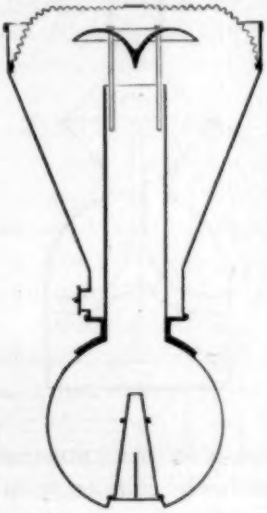
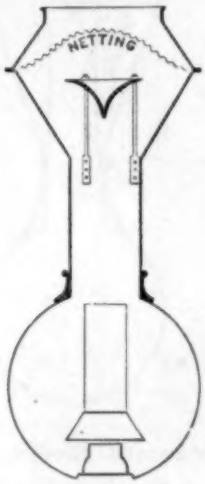


Fig. 4.

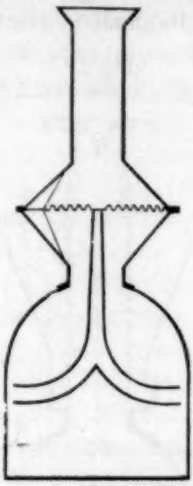


The principle of the bonnet pipe was preserved and employed under various modifications, from its conception by Dripps, in 1834, to the diamond stack of to-day, and among its various forms, one which found considerable favor, and is still in use, is that designed by John P. Laird for the Pennsylvania Railroad about 1864 (Fig. 5), in which the reduction of the size of the outer casing appears to be the distinguishing feature.

Returning to the order of dates, the next spark arrester, which, after the invention of the bonnet pipe, appears worthy of notice, is that of William Schultz, of Philadelphia, patented March 31, 1836 (Fig. 6). This may be described as in the form of the present diamond stack inverted, with its deflector removed and the exhaust nozzles passing through the netting. Schultz's stack was used on the Philadelphia and Columbia Railroad, and some of them were to be seen there up to the time that the road came into the possession of the Pennsylvania Railroad Company.

Fig. 5

Fig. 6.



Longmire and Brooke, of Philadelphia, in 1840, proposed to prevent the escape of sparks from locomotives by carrying them into the ash pan. Their plan contemplated extending the exhaust pipes *downward* into a flue passing horizontally under the boiler, into or below the ash pan, "so as to cause the sparks, with the waste steam and the gaseous products of combustion, to be discharged into a compartment prepared therefor, or into the ash pit, allowing their final exit to be downwards, or on or towards the ground." It is probably needless to state that if this apparatus worked on paper it would not on a railroad, and it has not, like some other impracticable suggestions, been periodically re-invented. In the latter respect, however, it differed from the "spark extinguisher" of David Ritter, patented November 26, 1840, which is noticed here only for the benefit of the inventor who may be so unfortunate as to develop the idea that he can carry the sparks and cinders through a horizontal pipe leading from the stack over the top of the train and discharge them at the rear end. Numerous patents have been granted since that of Ritter, for inventions embodying the same principle, none of which appear to have made any practical record.

In the Farrand spark arrester, patented August 19, 1873, which is shown in Fig. 7, the cinders are claimed to be separated by curving the top of the stack forward and downward into a chamber from

which the smoke and gases escape through two short vertical discharge flues, while the cinders may be returned to the fire box. This, like the Stevens stack of 1876, is substantially a reproduction of the principle of W. S. Montgomery's spark extinguisher, patented July 28, 1838.

Fig. 7.

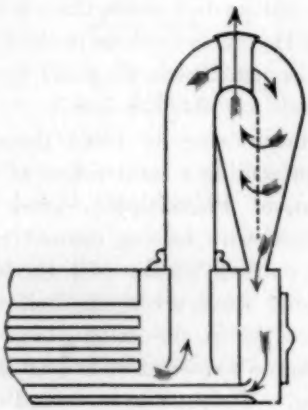
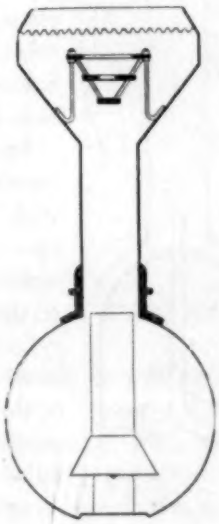


Fig. 8.

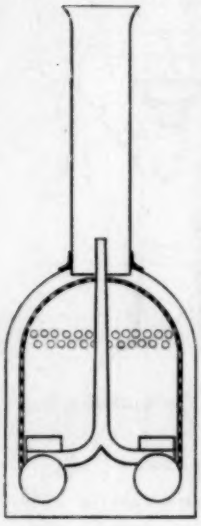


The Hughes spark arrester (Fig. 8), patented September 16, 1873, has been found to work well on anthracite coal burning engines. Its features are a deflector composed of a central disk with two separate rings of greater diameter above it, and an upper supplemental cone which can be adjusted in position to vary the draught.

In each of the several devices thus far referred to it will be noticed that the apparatus by which the sparks and cinders are to be separated from the smoke and gases is located in or connected with the stack. We shall now examine a different class, which, though not of recent origin, has of late years been revived and made the subject of strong claims as to its merit and utility, namely, that in which the separating and arresting apparatus is located either wholly or partially in the smoke box. This we may not unreasonably expect to find as an adjunct to English practice, in which the adoption of American improvements has been more limited and tardy than on the Continent of Europe. The English patents of Samuel Hall, No. 8792, Jan.

14, 1841, and No. 9345, May 9, 1842, show the earliest smoke box deflectors we have been able to discover; the same being in the form of a perforated metallic plate, passing around and above the front ends of the tubes, and having the exhaust pipe carried through it into a straight open stack, as shown in Fig. 9. A horizontal perforated deflector placed across the smoke box above the top row of tubes, as used by Hovey and others in the United States in 1863, was patented in England by Wm. Geo. Beattie, March 5, 1864, No. 559.

Fig. 9.



In the Baldwin drawing of 1860, the sketch numbered 45, representing a construction of Eastwick & Harrison, of Philadelphia, dated 1840, shows a cylinder of wire netting connecting the series of separate exhaust nozzles with the bottom of the inside smoke stack, about one-half of the cylinder being located in the smoke box. The usual upper netting or bonnet extends over the top of the outer casing. We can find no record of the performance of this apparatus, which probably failed by reason of offering too great an impediment to the draught.

R. A. Wilder, Engineer and Superintendent of the Mine Hill and Schuylkill Haven Railroad, next appears in this category, as the inventor of a perforated truncated cone of wire netting, extending from the nozzles of the exhaust pipes to a point above the base of the stack, and designed to intercept the sparks and cinders while giving passage to the lighter products. This he patented in 1854, in a combined feed-water heater and spark arrester, which was used on the anthracite coal burning engines of the Mine Hill and Schuylkill Haven and other roads. An illustration and description of the Wilder stack will be found in the JOURNAL OF THE FRANKLIN INSTITUTE, Vol. 33, 3d series, 1857, p. 414, and it is shown in the accompanying Fig. 10, as applied to the Baldwin eight-wheel connected engine, "No, 29," of the Mine Hill road, from an article upon which, by Colburn, in the *Engineer* (Philadelphia), of October 18, 1860, p. 77, we make the following extract, which clearly describes it:

"The smoke box is made of ⅜-inch iron, and supports a heater, spark arrester and chimney of peculiar construction. A tapering pipe,

of coarse wire cloth, 21 inches in diameter at the top, 10 inches diameter at the bottom, and 3 feet 6 inches high, descends 10 inches below the top of the smoke box. The exhaust pipes, with nozzles 3½ inches diameter each, come up to and enter the bottom of this pipe, which is otherwise closed by a plate of perforated iron. The heated air and sparks ascend around this netting pipe, which is surrounded at a distance of 6 inches by an outer casing of stiff iron, and which is thus about 33 inches in diameter at the top, 30 inches high above the smoke box and 24 inches diameter at the bottom. The fine coal carried through the tubes is thrown down by the meshed sides of the netting pipe, the products of combustion passing through and up through a straight open pipe 14¼ inches in diameter above. * * * * *

Fig. 10.

The spark arrester has been described, but it should be said that the fine coal and sparks thrown down by the nearly vertical sides of the wire netting pipe, drop through a large opening in the bottom of the smoke box, and into a large iron spark box beneath. This box is cast very heavy, and is really the bed plate of the cylinders, broad flanges on which are strongly bolted to its sides. In the bottom of this spark box or hollow bed plate is a valve through which its contents may be discharged at pleasure upon the track."

Wilder's engines had long exhaust pipes and no draft or lift pipes, as in the universal English practice, and a perforated cone, identical in principle with his, was patented in England by W. G. Beattie, March 5th, 1864, No. 559, and C. Moriarty, September 10th, 1864, No. 2219, the latter forming his of "stretcher rods" of iron wire instead of the usual netting. Beattie's cone is shown in Fig. 11.

E. May, of Boston, patented a cylinder of wire netting, extending from the exhaust pipes to the stack, July 28th, 1857, and A. S. Sweet, Jr., of Detroit, patented double cylindrical deflectors on a similar principle June 23d, 1863, after which nothing more appears to have been done in this direction until 1870, when the Wilder perforated cone, "in combination" with the ordinary American draft pipe, used for a long time theretofore with short exhaust nozzles, was again patented in the United States by James Smith, and has been adopted

as a standard for their passenger engines by the Pennsylvania Railroad Company, using both anthracite and bituminous coal, and by several other roads burning anthracite exclusively. Fig. 12, from *The Pennsylvania Railroad*, by James Dredge, London, 1879, shows the Smith stack as used on the Pennsylvania Railroad and branches.

Fig. 11.

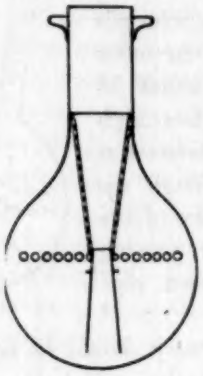
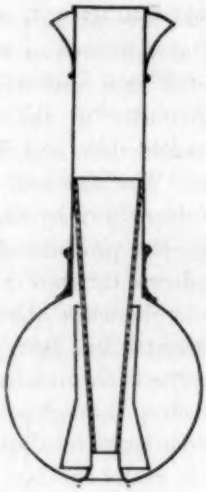


Fig. 12.

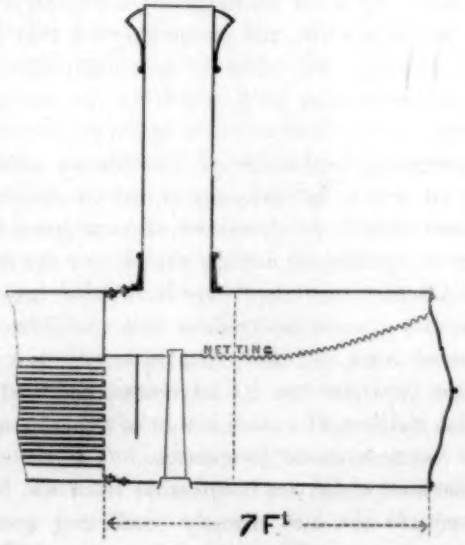


The perforated cone possesses, in principle, no advantage over the diamond stack, beyond the possibility of obtaining a larger amount of separating surface, and so far as the use of bituminous coal is concerned, the Smith spark arrester does not, in practice, exhibit any material reduction in the amount of cinders and sparks expelled, as compared with a bonnet or diamond stack of the average construction.

Our history may be closed with a notice of the Hovey spark arrester, the latest form of which has been within a few years past introduced on the New York and New Haven Railroad, and the distinguishing characteristic of which is a longitudinal extension of the smoke box, to form a spark receptacle, and the use of deflectors between the tube ends and lower opening of the stack. A smoke box extended forward of the stack was patented, as a spark arrester, by John Thompson, of Boston, May 29th, 1860, upon the theory that the sparks would "pass out of and beyond the current of smoke, so as to

be deposited in the box by the action of gravity and not carried up the chimney." A very brief consultation with any experienced locomotive fireman might have led Mr. Thompson to the knowledge that sparks will not behave in this accommodating manner, and an investigation of authorities on boiler engineering would have taught him the fallacy of increasing the dimensions of the smoke box where economy in the consumption of fuel is to be kept in view. His plan never received acceptation from its manifest impracticability, but an attempt to improve it was made by Jacob Hovey, at the time master mechanic of the Cleveland and Pittsburgh Railroad, who added to the Thompson extended smoke box, horizontal deflectors, placed above the upper row of tubes, patented the arrangement April 7th, 1863, and placed it upon a number of engines on the Cleveland and Pittsburgh Railroad. The accounts of its performance on that road were eminently unsatisfactory, engines failing for steam and smoke boxes sometimes becoming red hot in parts from the ignited cinders with which they were partly filled, and the apparatus was permanently abandoned by the Cleveland and Pittsburgh Railroad. Since the early and unsuccessful

Fig. 13.



efforts of Hovey, the extended smoke box system has, from time to time, been taken up by other parties, and has culminated in the

arrangement adopted by the New York and New Haven Railroad, shown in Fig. 13, in which a vertical sheet iron deflector is placed at a distance of about nine inches in front of the flue head and extends to a point about twelve inches above the bottom of the smoke box. This deflector is perforated only for a short distance above its lower side, and a horizontal imperforate deflector extends from the flue head to a point a few inches in advance of the long exhaust nozzle which passes through it. A sheet of wire netting extends from the front of the horizontal deflector to or near the front end of the smoke box, the interstices of which netting form the exit openings for the products of combustion passing to the stack.

R. Hill, in 1873, patented a vertical imperforate deflector and netting in the ordinary smoke box, and S. A. Hodgman, in 1874, a perforated plate in front of the flue head, with a hinged damper on its lower side. The employment of Hill's deflector, which has been embodied in the extended smoke box arrangement, as shown in Fig. 13, is apparently advantageous, and if such a deflector was combined with a smoke box of normal dimensions and a spark arresting stack, all the benefits of the extended smoke box plan, if any there are, would be retained. Such an arrangement, however, does not appear to have been put in practice, and in the only use that has so far been made of the deflector, its value is practically destroyed by the faultiness of a construction with which it has no legitimate connection.

From the preceding retrospect of the history of the locomotive spark arrester, in which we have attempted to sketch merely a few leading features which have characterized its progress from its primitive form, that of a grating or netting placed over the top of the stack, to the present practice, the latter may be divided into three general classes: the bonnet pipe, as modernized into the diamond stack; the Wilder perforated cone, and the extended smoke box with its inside deflectors. Each of these has its advocates, and each is sufficiently open to objection to demand a continuance of experimental research by designers and constructors of locomotives. The defects of the first two systems are those which are inseparable from the impossibility of reconciling perfectly the two directly conflicting conditions which necessarily obtain in any and every spark arrester, but those of the

third embrace in addition a radical error of principle and practical disadvantages which combine to more than neutralize any merit it may be claimed to possess. In the formation of this opinion the writer has been governed as well by the dicta of acknowledged authorities as by his own observation of the operation of the long smoke box, and if the expression of his views should succeed in eliciting evidence that he is incorrect, another step will have been attained towards directing the efforts of locomotive engineers to produce a practically perfect spark arrester, in the channel which leads to success.

The error of principle alluded to lies in *expanding* the capacity of the smoke box, the dimensions of which, in the ordinary construction, are too great. In support of this proposition there can be adduced the opinions of Zerah Colburn and Daniel Kinnear Clark, both of whom were engineers so eminent, as well in practice as in theory, that their writings have received general acceptation as standard authority on questions relating to locomotive engineering. From an article by Colburn, on "Proportions of Locomotive Boilers," published in the JOURNAL OF THE FRANKLIN INSTITUTE, Vol. 27, 3d series, 1854, pp. 194-199, we make the following quotation:

"Another means of improving the working of locomotive boilers is in forming a better connection of the tubes and chimney than is afforded by the ordinary 'smoke box.' The direction of this passage must be eased, *and its contents reduced to the smallest possible extent.* The use to which the upper part of the smoke box is generally placed has prevented the separation of that part from the general contents of this chamber. The steam pipes and throttle box, for the want of a better situation, have been placed here, and often in such a manner as to stand in the way of the draft. A plan which I proposed some time since for the relief of the draft of engines on a line having low bridges, which plan I have lately learned was tried with good results some years since on the Columbia road, but for some reason was not continued in use, was to place a level sheet of iron across the smoke box just above the upper row of tubes. This would reduce the contents of the smoke box and consequently the amount of air to be lifted out. It would allow of extending the chimney downwards, and of thereby increasing the effective length, and also of lowering the blast pipes and substituting blast pressure for blast suction. I look to this plan as one likely to become generally applied."

The views of D. K. Clark are to the same tenor, and he verifies them by results obtained from actual experiment with engines in England. (*Railway Machinery.* London, 1865, p. 137.)

The soundness of the principle enunciated by Colburn, and the adoption of the plan he proposes, are further attested by the French engineers Le Chatelier, Flachat, Petiet and Polonceau. In their treatise, the *Guide du Mécanicien Constructeur et Conducteur de Machines Locomotives*, Paris, 1859, under the head "Boite a fumée" (smoke box), they say, on pages 113 and 114: "The dimensions of the smoke box should be, *on principle*, as limited as possible, for the immediate effect of the draught produced by the exhaust is to dilate the air comprised in its capacity; this rarefaction being operated by reason of the diminution of pressure which is the consequence of the draught, the hot gases which fill the tubes, and after them those which fill the fire box, rush into the smoke box to give place to the fresh air which the difference of pressure causes to pass through the grate and fuel. It is evident that for the same action produced by the exhaust of the steam in the chimney, the dilatation will be as much greater in the smoke box as the volume of the latter is smaller, and as a consequence the suction of air through the furnace will be more energetic. It appears, nevertheless, that there is in practice a limit to this reduction of the dimensions of the smoke box, below which it ceases to be advantageous. One of the best means of causing this reduction consists in placing a horizontal plate above the upper row of tubes and lowering the chimney to this plate, which is fastened by angle iron to the vertical surfaces of the smoke box. (Pl. 9, Fig. 2.) Mr. J. J. Meyer, of Mulhouse, has applied this arrangement since the year 1854 to locomotive engines ordered from him by the Austrian Government, which in its turn has adopted it for the remainder of its stock. Many French constructors have also adopted it. Independently of the reduction of volume, there are many advantages in thus isolating the upper portion of the smoke box from the lower. The chimney is considerably lengthened, and the exhaust pipe shortened, and the joints of the steam pipes are not altered by the action of heat."

A smoke box reduced in dimensions as proposed by Colburn is shown in Plate xliii of *Recent Practice in the Locomotive Engine*, London, 1860, representing a passenger engine built by Sharp, Stewart & Co., Manchester, for the Egyptian Railway.

The authorities cited merit consideration, and it can scarcely be maintained upon mere assertion that the position assumed by them upon this question is an erroneous one, especially as it accords with the universal practice in marine and stationary boilers, as well as with that of all locomotive builders in this country and Europe, except the comparatively small number here who have adopted the extended smoke box arrangement.

The practical disadvantages of the extended smoke box are, in addition to greater cost of construction and maintenance, the increase of weight which it throws upon the truck, and the necessity of cleaning it at the end of the trip. Accurate data as to the percentage of unconsumed coal which passes out of the front end of the tubes of a locomotive cannot probably be obtained, but it is obviously a large one. In a report on the tests of a Baldwin 16×24-inch engine, on the Cincinnati, Hamilton and Dayton Railroad, made by John W. Hill, M.E., and published in the JOURNAL OF THE FRANKLIN INSTITUTE, April and May, 1879, Mr. Hill states that of the coal charged per foot of grate not less than *twenty* per cent. must have been blown unconsumed out of the stack, and adds: "The facility with which a locomotive boiler operating under a strong blast can distribute unburnt coal along the track is well known, but it is doubtful if the percentage of coal thus disposed of is equally well known. Under the ordinary conditions of locomotive performance, with careful firing and regular blast, the loss of coal by this avenue is, in the writer's opinion, rarely less than *five* per cent." As another estimate, it may be added that in the specification of a recent patent to a locomotive builder, the statement is made that there is "a waste of fuel, amounting to nearly fifty-five per cent., caused by the too rapid passage of the products of combustion through the tubes and by the premature escape of unconsumed fuel in the condition of gases and ignited sparks."

Whatever the actual average percentage may be, it is clear that it would be impossible for an extended smoke box, even when exaggerated, as in some instances, to the length of seven feet, to contain all the sparks and cinders which escape from the tubes during the ordinary run of a passenger engine, and therefore they must, with the exception of those which at the commencement of the trip bank up in the front end and are transported uselessly, be driven through the netting and out of the stack. No advantage, either theoretical or practical, appears in this method of expulsion over that practiced

with the bonnet pipe or the perforated cone, and the objections, both of principle and in practice, are too undeniable to be explained away by the vague assertion that the arrangement is "cleaner" than the former ones.

If the position herein taken, that the extended smoke box is a departure from sound theory and progressive practice, be a correct one, the length at which strictures upon it have been presented will be neither objectionable nor devoid of value; and, if not, it is evident that the only other systems of spark arresters which still remain to any extent in use, namely, the bonnet pipe and the perforated cone, should be relegated to the past, and the improvement of the extended smoke box arrangement be recognized as the single avenue to success for all those whose endeavors are directed towards the perfection of this department of locomotive engineering.

Magnesium Steel.—A half per cent. of magnesium changes coarse-grained into fine-grained steel and greatly improves the quality. The magnesium is introduced through an opening in the cover of the crucible, after inserting some small bits of charcoal, in order to remove the free oxygen. Without this precaution there would be danger of an explosion.—*Ber. der Chem. Gesell.* C.

Twin Locomotives for a Portuguese Tramway.—The tramway from Villa Real to Villa Regoa has grades of ·08 (422·4 ft. per mile). Mule service, which was first intended, being deemed insufficient, it was decided to try a new plan, with special engines from Winterthur. There are two locomotives, with a metallic frame-work suspended between them, on which rests a platform for the freight. The frame is made of iron beams, 11·5 metres (17·5 yds.) long, and ·45 metre (1·476 ft.) high, fastened at their ends to the two locomotives and firmly joined together. The platform is 8·1 m. (26·575 ft.) long and 1·9 m. (6.234 ft.) wide, 0·67 m. (2·198 ft.) above the rails, weighing 3·3 tons and with a carrying capacity of 15 tons. The locomotives have six coupled wheels, so united to the frame-work as to permit an easy passage over the abrupt curves, many of which have a radius not exceeding 25 metres (27·34 yds.) Air-brakes are attached to the ordinary brakes, for greater security.—*Ann. des Ponts et Chauss.* C.

STANDARD SIZES IN CYLINDRICAL FITTING.

By GEORGE RICHARDS.

Read before the Franklin Institute at its meeting Dec. 17th, 1879.

At previous meetings the writer has had the pleasure of presenting before the members of the Institute, descriptions and examples of the system of standard gauges which is being advocated as a means of cheapening the cost of producing machine parts, based upon a uniformity of sizes and interchange of like parts.

Since that time the adoption of such gauges, for a long time considered problematical, has fully equaled the most sanguine expectations, and to the present time more than five thousand of the different forms of standard gauges being made, have been adopted by various shops in this country and in England. It is a pleasure to refer also to measuring machines, an inplement that was unknown in a tool room in this country, so far as the writer is aware, until a few months ago. The twenty-eighth machine is now in progress. A very fine example is presented this evening, just completed for one of the government arsenals. The readings are to the one ten thousandth part of an inch, but variations to the one hundred thousandth part of an inch can be indicated by the machine.

It will be noticed that the machine is arranged with two screws, one for measuring, the other for approximate adjustment in setting the points to standard length bars. The measuring points, which in this machine are in line with the screws, are made in two forms—with spherical and flat points, one set of each being used at a time.

The error in the aggregate and relative pitch of the measuring screw is provided for by the improved methods presented before the meeting a short time since. The screw is immersed in oil to maintain a uniform temperature throughout its length and to avoid particles of dust accumulating on its surface. The machine receives pieces to twenty-four inches in length and to four inches in diameter.

Referring again to the increased use of standard gauges: it seems now to be generally conceded that these implements are no longer to be regarded as a luxury, but an essential part of an equipment for manufacturing machines. Their low price, together with the advan-

tage gained by their use, being more generally understood, will account for this.

Until recently the writer had only engaged his attention with the means of establishing sizes and testing the accuracy of finished parts, but since a source of trouble has arisen in many cases where it was assumed that the possession of standard gauges alone accomplished the desired results. Some farther means of maintaining the sizes seems to be called for.

Every one at all acquainted with shop manipulation, is fully aware of the fact, that before much can be accomplished in the right direction, the holes in the various parts of machines must be finished with some degree of uniformity, to permit of gauges and proper mandrels being used to advantage.

Having been obliged from circumstances to base most of the precedents in this manufacture upon the English system of work, in which standard gauges have for many years been very generally employed, the fact was partly overlooked, that in their practice holes were bored to size, while here reaming tools were almost universally adopted.

To explain the cause of the difficulties which necessarily arose where reamers of the usual type and gauges were used together, attention is called to an example of such a reamer. It consists of a piece of hardened steel with cutting edges about one-half its length, while the other is of cylindrical form (called generally the "shank"), serving in most cases as an extension or handle to reach through deep holes. The cutting edges are ground to finish a hole to standard size when the implement is new. It is no doubt intended that the shank shall be a guide for the cutting edges, after they are fully entered in the hole being reamed, but it will be readily understood that the cutting edges being continually subject to wear, that to make a commercial success of such a reamer, the shank must be small enough to pass through the hole made by it, without reference to the amount of wear that may occur from continued use.

From this it will be seen that such an implement, without any means of maintaining its original size, can have no reference to standard sizes, except when first used. As the holes made in this way gradually diminish in size, the gauges will not enter the holes, the diameter of cylindrical pieces must also be reduced, and proper mandrels of steel cannot well be employed. The results will, in most cases, be a worse confusion than if no system were attempted at all.

It is of course suggested that such reamers be annealed, reset, hardened and ground; as special skill is required for these operations, they rarely receive such treatment, but as many here can testify, are instead reduced to another size.

For these reasons, it has become necessary to supplement the standard gauges with some implement to produce holes to uniform sizes, and the manufacture of an adjustable reamer of the type at present employed in some of our leading shops, has therefore been entered upon. The form of the reamer is well known in Philadelphia, owing to the extent to which gauges are used here. It consists of a steel body with inserted blades, upon which the cutting edges are formed. The grooves in which the blades are fixed are not parallel with the centre, but at such an angle, that the blades being forced towards the shank, the diameter of the outside of the cutting edges is increased.

Such reamers have from time to time been made, with the usual appliances at their command, by those shops where a system of uniform sizes has been adopted, and have no doubt formed the principal means of maintaining such a system after being begun.

The feature of adjusting the size of a reamer as it wears, brings an entirely new set of conditions to bear on the matter (when compared with the solid ones). It permits of an uniform difference being constantly maintained between the diameter of the cutting edges and the shank. In this case, the shank can be utilized as a means of guiding the cutting edges, to insure straight holes being formed, and still farther form a means of determining the wear to be permitted, as it becomes a check to the use of the reamer when it requires readjustment.

Inasmuch as different grades of fitting will allow of more or less variation in the holes, this limit of accuracy, as it may be called, can be regulated with some degree of certainty. This matter will be dealt with farther on. Attention is called to the general plan of the reamer as an example of fitting and accurate workmanship. It becomes an example of the results possible in producing duplicate parts with accurate means of measuring, in connection with tools made to standard sizes. This form of reamer has always been considered difficult to make, owing to the nature of the fits, but with a view of reducing the cost of them, to allow of their being generally used instead of the solid reamers, it was necessary to base their manufacture upon milling the dovetail slots uniform in size, and producing the blades without reference to their final disposition in any one reamer. The blades

are fitted to drive tightly, so as not to be altered in position by any rough usage they may be subjected to. The blades being interchangeable, they can be renewed when worn to the limits of end adjustment. The plan of holding the blade by tight fitting has an object, in preventing the size of the reamer being tampered with by unprincipled workmen, and to insure that it is altered only when worn sufficient to require re-adjustment. Messrs. Wm. Sellers & Co., of this city, have adopted a very good plan in their reamers for this purpose. The blades are driven out from the shank to expand the size. The blades are then ground "flush" with the ends of the stock, showing at a glance if the blades occupy their proper position. This plan, however, presents some difficulties in the manufacture of the reamers that overbalances this advantage; any *convenient* method of adjusting the blades would thus seem a detriment.

It might be explained, that in perfecting mechanism to insure this interchange of parts, an equal number, if not more, difficulties have been encountered than in the making of the gauges. The work is required to be uniform, to about the one five-thousandth part of an inch, which is comparatively a much closer degree of accuracy, where results are based on the maintenance of cutting tools, than in the gauges, where the sizes are obtained by grinding and many tests being made.

In beginning the making of cutting tools to be used in finishing working parts of machines, a step was taken outside the province of gauge making, which had only been directed to furnishing standards to make work to, leaving it to the discretion of the user to determine how the finished parts should fit with the gauges. There had always been some misgivings about this matter, from noticing results after standard gauges were employed, and upon further inquiry, quite a difference of opinion was found to exist. Research was at once begun, to arrive at some definite conclusions, and it is hoped no egotism will be attributed to the writer, when it is explained, that it was assumed whatever such inquiry might determine, those adapting standard gauges would, to a certain extent, be compelled to accept. As the matter is one of general interest, it has seemed proper to place before you the results of the investsgations, with the reasons for certain plans being adopted in the construction of the adjustable reamers.

The question that has called forth this paper is, what relation shall the sizes of holes in machines bear to standard measurements; or, in

other words, shall holes be made above, exactly to, or below standard sizes?

In order to cause the argument to be more readily followed in entering into details, it will be proper to call attention first, to the conditions that must exist in any practical attempt to produce parts exactly similar. Different classes of manufactured products call for more or less uniformity in their parts. The controlling element, in most cases, being the destruction of the cutting edges, coupled with slight inaccuracies in the working details of the mechanism actuating the tools.

There is a defined limit to this matter of making parts duplicate and interchangeable in machines, based upon conditions so numerous that no attempt will be made to point them out here. Even when satisfactory results are arrived at, the sizes of duplicate parts can at best be only an approximation to some arbitrary or standard size, but should at all times be within some defined limits, the degree of accuracy established for the work being an exponent of this.

For example, let us suppose that a variation of one hundredth part of an inch is permissible in a certain class of work; in that case an inch, as expressing a size, could be one inch plus one two-hundredth, or one inch less one two-hundredth part of an inch, and yet be regarded as a duplicate of a standard inch, in that particular instance. In making standard gauges, guaranteed to be uniform to the one ten-thousandth part of an inch, as compared with original standards, the gauge may be larger or smaller than this original to the extent of one twenty-thousandth part of an inch. Were it possible to adjust the gauges to the one-millionth of an inch there would still remain the same conditions, in so far as approximating a uniformity in sizes.

This variation then represents the change which tools may be permitted to undergo and yet remain in use for a specific purpose.

It will now, it is hoped, be granted that it is a matter of much importance to arrive at some very definite conclusions about the relation that the sizes in machine fitting should bear to standard sizes. It has been pointed out, that with proper appliances for making the holes, they become the basis in carrying out a system of uniform sizes. Should the implements for finishing the holes be adjusted at first with an allowance made for their wear, to make the holes larger or exactly to a standard size hole?

The difference in the two cases is more than would at first be

imagined, and in actual practice is of sufficient moment to warrant the assertion, that even with similar standards in each shop throughout the country, there cannot be said to exist any uniformity in the sizes of their finished product. The difference in the results will at all times be double the limit of accuracy that is assumed in fitting. In one case a 2-inch hole would at first be $2\frac{1}{100}$ inches and diminish in size to 2 inches, while on the other, it would be either 2 inches or 2 inches less one-hundredth, the difference in comparing the results together, being really one fiftieth of an inch.

It will now be well to consider what should be the proper basis, in attempting to arrive at any definite conclusions on the subject.

Some of the different forms of standard gauges used in determining sizes in fitting are exhibited to assist in the matter.

The nature of the surfaces on a pin and ring gauge permit of their both being very nearly the same size. One-tenthousandths of an inch difference in either would make a marked change in the fit. To illustrate this, an example of two gauges with this difference in size is presented for inspection by the members. It would require perhaps a thousandth of an inch in even good fitting to produce the same apparent change in a shaft and hole.

Inasmuch as the close fitting of gauges cannot be carried into practice for this reason, either the internal or external gauge must be assumed as a shop standard.

Everything pertaining to the duplications of standards requires that the external gauge or a length standard be assumed as a basis. The standard lengths of Great Britain, adopted by our government, are bars with points, the outside dimension being the standard length.

In reproducing duplicates, measuring points are brought in contact with the ends, and the distance between them assumes the form of a gauge for that purpose, but not of a standard length.

Referring now to the interchange of different forms of standard gauges, the length standards are represented by pin gauges, the corrective gauge disks, and the "heel," as it is generally called, of the fixed caliper gauge, while outside measures for transmitting these length are represented by the measuring machine, the ring gauge and the fixed calipers.

The latter implements indicate a standard size plus two contacts, or in the case of the ring, of a continuous contact.

The amount of surface contact becomes of much moment in the fit-

ting of standard gauges, owing to the nature of the surfaces and the density of the material employed. The distance measured between the points of a fixed caliper gauge is less than the internal diameter of a ring gauge indicating a similar size, because of the small amount of surface in contact in the former. Again, the internal diameter of a cast iron ring gauge must be greater than one of hardened steel, each appearing to fit the same over a cylindrical gauge. This difference is even more when both are fitted to a pin gauge of cast iron.

From these few examples it will be understood that the duplication of gauges is based upon assuming outside dimensions as the standard.

For these reasons it has been thought best to recommend that in fitting, the size of the holes should be above standard sizes enough to show a contact with a standard size shaft similar to the apparent fit of the gauges with one another.

To refer again to the variations in duplicating parts, as representing only an approximation at best, the different degrees of fitting must now be brought to bear on the matter.

Even if holes are assumed to be made uniform, the size of cylindrical parts must be varied to produce the different contacts referred to in the gauges.

In practice, fits are divided generally into three kinds: first a driving or forced fit; second a close contact or exact fit, and, third a fit loose enough to permit of the surfaces being lubricated by the ordinary means.

To now bring the three conditions that have been explained together: the standard gauges in their various forms; the variation that must occur from wear of tools to form holes, and the different grades of fits employed in practice, it would appear that to suit these conditions most favorably, the slight variation permissible in the holes, compared with a standard size shaft, should represent the fit described as a close one—neither a loose or forced fit. Compared with the gauges now, this fit would show a similar contact with them, the fixed caliper going easy over the shaft and the "heel" of the gauge entering the hole apparently with a similar contact of the shaft. If the fit were a forced one, the shaft would be larger than the gauge, and if a loose fit, smaller than the gauge. Provided the cylindrical parts of machines were prepared in this manner, without reference to the holes, the variations that must be made in their size to fill the conditions of the different fits, is so much more than the variation that

should be permitted in the holes, that practically no difference would be noted, whether the size of the hole is at one extreme or the other.

To again call your attention to the adjustable reamer, as perhaps affording farther explanation: the shanks of the reamers are duplicates of standard cylindrical gauges, while the extreme diameter of the cutting edges is the standard size plus the variation or limit of accuracy assumed in the work.

The shank at once assumes a new condition as a part of the reamer. It can be considered as a guide to insure straight holes, but its most important function is as a check, to limit the use of the reamer when it has diminished from its original size to the smallest diameter that is permitted from the degree of variation assumed in the fitting. Practically, this forms the only safe means of controlling the sizes in a shop, without continued attention on the part of the manager.

Without such an implement, the conditions of fitting referred to would be impossible, and standard gauges could be utilized only to a limited extent in fitting.

Mandrels should receive some attention as having a bearing on the matter. When properly used, they should be divided into two classes, for long or short holes; in one case being made straight about one-half their length, with a taper on the remaining part, in the other with a gradual taper from end to end. One end of them will in either case be to standard size, as the holes cannot be made too small to prevent their being entered.

To conclude by drawing comparisons between the system to be attained by using adjustable reamers, in contrast with what could be accomplished with solid reamers, it might be inferred that an extreme position has been taken in the matter, based upon anticipated pecuniary returns from the sale of such reamers, but as they form the only means of making the gauges practical implements (in which it is assumed you are all interested), coupled with the fact that they must be sold, although much more costly, at about the same prices as solid reamers to induce their use, it is hoped that the spirit in which this subject is treated will be properly understood. The object is only to point out the means which must be employed to reduce the cost of machine fitting by a systematic duplication of parts.

SAWS.

By Robert Grimshaw, Ph.D.

The saw is one of the most ancient, useful and familiar of tools. The generic term applied to a serrated dividing tool is generally understood as applying to a saw for wood, although the implement is used also for bone, stone, metal, ice, etc.* (There is also a familiar limitation to a reciprocating hand tool). The ancient Egyptians, far back in the silent centuries, knew and used this tool, the material being bronze, hardened by an art now lost. The Greeks, masters of many and far-sailing wooden ships for war and exploration, deified the inventor, who comes down to us as Talus or Perdrix. The original saw was, doubtless, a flat notched or jagged piece of metal like a nicked knife blade, having no special form of teeth, but used with a straight reciprocating stroke, and for either ripping or cross cutting. It cut on both strokes. The saws of the stone age had flakes of flint imbedded in a wooden blade and held by means of bitumen. The Mexicans used obsidian for saw teeth. The South Sea Islanders employ sharks' teeth, and the Caribs use notched shells.

The saw is mostly used for converting wood and other materials from original forms, and naturally precedes the plane and other tools, although it follows the ax. It does its work with considerable speed and accuracy. In some elaborate and highly ornamental arts it is nearly the only tool used.

The importance of scientific and economical timber-cutting may be conceded when it is asserted that the annual value of the wood, lumber and timber crop of America is a billion dollars ($1,000,000,000), or four times that of our wheat crop. The immense waste in cutting timber, with the millions of axes now in use, is almost incredible. The tough and knotty timber and chips now wasted in cutting cord

* Stone sawing, in the ordinary sense of the word, is not sawing, but abrasion in a narrow line by means of loose sand or iron shot, pressed in by a reciprocating blade, while it is also accomplished by diamonds set in iron blades. So-called "saws" for india-rubber and some of those for cold iron rails are plain unserrated disks, no more to be considered under the head of saws proper than Miss Edgeworth's essay on Irish Bulls among works on Natural History.

wood might be saved by cross cutting with saws into short blocks, say one foot long, making good stove wood.

It is computed that the saving of timber and time by the scientific use of saws would equal the interest of the United States public debt; to say nothing of lightening the toil of millions of farmers.

As we now know the saw it is either RECIPROCATING or CONTINUOUS in action; the first class having a flat blade and practically *straight edge* and making a plane cut; and the latter being either

(1) a *circular rotating disk*, cutting in a plane and at a right angle to its axis;

(2) *cylindrical*, or barrel-shaped, with a convex edge, cutting parallel to its axis; or

(3) a continuous ribbon or *band*, running on two pulleys and making a plane or curved cut, with a straight edge, parallel to their axes of rotation.

There is a fourth class, or *spiral* saw, composed of segments clamped between plates, and cutting a dovetail joint (Armstrong's patent). The entering segments cut like a circular saw; subsequent segments are flanged—at first slightly, and gradually more and more; these later segments have the cut of a cylinder saw. As the flange wears away by filing, the segments are moved on towards the unflanged end of the spiral.

Between the *Reciprocating Rectilinear* and the *Continuous-acting Curvilinear* saws may be classed the *Chain Saw;* its many varieties having either one or two axes, at right angles to the plane of cut; cutting with either a concave, a convex, or a straight edge, and either reciprocating or continuous in action. It is essentially a saw composed of *links* like a chain, and is a connecting link between the two other classes.

We shall consider these classes in sequence, after having gone into the theory of the shape, disposition and action of saw teeth, as applied to the earliest, simplest and most common class, that with reciprocating rectilinear blade.

The blade of this kind of saw is usually a thin sheet of steel, rolled evenly thick, having the teeth then cut out with a punch; the blade then smithed or pressed perfectly plane or flat; ground, principally crosswise, to perfect the surface and reduce the thickness at the back; the teeth then sharpened and set.

This class of saw has more forms of teeth than any of the others.

Its teeth are formed at greatly varying angles and made to cut either way or both ways; sometimes one series of teeth cuts in one direction and another in the opposite on the same blade. In the first case the effective or cutting stroke is either by pulling or by pushing. The carpenter's saw of the ancient Greeks was a straight frame, with perpendicular teeth, and two-handed—doubtless cutting both ways.

The saws of all Asia do not, and those of ancient Greece did not, employ the *thrust* cut, which gives the straightest cut and the freest from sawdust; but cut on the *back* or pulling stroke. But we shall refer to this subject later on, and consider now the outline of the teeth.

It is necessary to premise that the *pitch* of a tooth means the *angle* of the face up which the shaving ascends; not an *interval*, as with screw threads. Small teeth are counted in *points* to the inch; those of large saws by the space expressed in *inches* or in parts of an inch.

The real angle of a point is found by subtracting its back angle from its front.

The generic angle of saw teeth is 60°; being that of an equilateral or "three-square" file. But this may be variously placed.

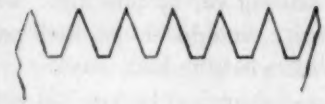
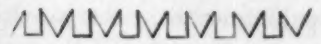
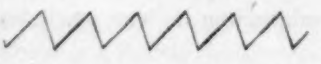
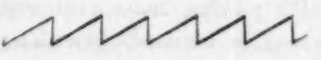
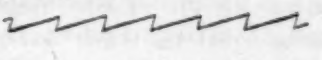
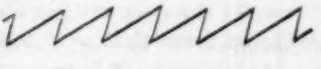
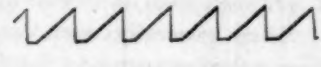
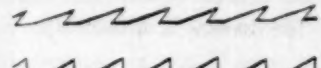
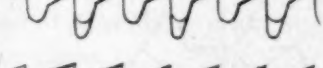
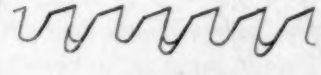
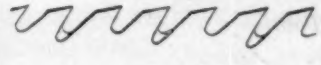
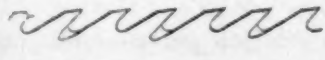
In the annexed table of angles and spaces the pitches are classified 15° asunder. Thus, in Fig. 1 D is upright, having no pitch; G is flat, having plenty.

The peg tooth, Fig. 2, has rather more throat room than a ∨ tooth (Fig. 3) of ths same width and height, and less than if it were cut deeper, as by the dotted lines, Fig. 4. Being generally more acute than 60° it could not be dressed with either a three-square or a flat file if in ∨ shape; as it is, a flat or "mill" file dresses it admirably.

Fig. 2. Peg Tooth.

Fig. 3. ∨ Tooth.

Table I.

	Simple forms of saw teeth, from Holzapffel.	Angles. Face.	Angles. Back.	Ordinary spaces. Inches.	
A	 Peg; fleam.	110°	70°	$\frac{1}{8}$—1$\frac{1}{4}$	
B	 Plain M.	90°	30°	1—1$\frac{1}{4}$	
C	Half Moon.	90°	35°	1—1$\frac{1}{4}$	
D	"Cross-cut"—no pitch.	120°	60°	$\frac{1}{8}$—1$\frac{1}{4}$	
E	 Small cross-cut—slight pitch.	105°	45°	$\frac{1}{8}$—1	Also 3 to 60 points.
F	 Pruning; ordinary pitch hand-saw; joiners; English cross-cut.	90°	30°	$\frac{1}{8}$—1	
G	 Metal; mill saw—soft wood.	75°	15°	$\frac{1}{4}$—2$\frac{1}{2}$	
H	 Some circular saws—pit; cross-cut; bath stone.	75°	30°	$\frac{1}{8}$—1$\frac{1}{4}$	
I	 Mill.	90°	50°	$\frac{1}{8}$—4	*
J	 Circular.	60°	15°	$\frac{1}{8}$—2	
K	 Hard wood cross cut.	90°	30°	$\frac{1}{8}$—3$\frac{1}{2}$	
L	 Pit; circular.	75°	20°	$\frac{1}{8}$—3$\frac{1}{2}$	
M	 Pit; circular.	60°	10°	$\frac{1}{8}$—3$\frac{1}{2}$	
N	 Soft wood; ripping.	45°	5°	$\frac{1}{8}$—3$\frac{1}{2}$	

Gullet or briar tooth.

A saw tooth has two functions—*paring* and *scraping*. A *slitting or ripping* saw for wood has the cutting edge about at a right angle to the

* Sometimes each alternate tooth is cut out; then it is "skip-tooth."

fiber of the wood, severing it in one place; the "throat" of the tooth wedging out the piece.

Fig. 4. Peg Tooth.

In a "*cross-cut*" *wood-saw*, also, the cutting edge strikes the fibre at right angles to its length, but severs it on *each side* from the main body, before dislodging it.

In the slitting saw, N, Fig. 1, the "rake" is all in front, where the cutting duty is. In the cross cut, as D, the rake is on the side, for the same reason.

The *length of tooth* depends largely upon the duty required. A long tooth has the demerit of being weak and liable to spring; the merit of giving greater clearance to the sawdust—a specially valuable feature in soft, wet or fibrous woods. It is certain that the throat space in front of each tooth must be sufficient to contain the dust of that tooth from one stroke. If (as in a short tooth) the space be not high enough, that quality can be gained by distance between the teeth. For hard

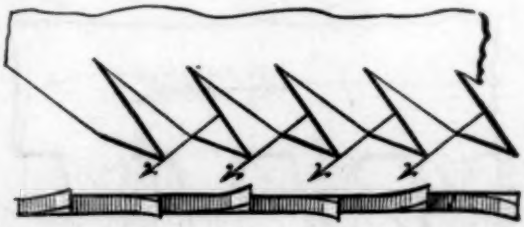


Fig. 5. Great Front Rake.

woods, where long teeth are inadmissible, it is best to have short teeth, wide spaced. The deeper the tooth the quicker the saw wears out.

The greater the feed the deeper the dust chamber required, or else the more teeth needed.

Equal length of teeth is of great importance; as inequality gives the longest teeth the most work and lessens the duty of the saw; giving fewer cutting teeth and dulling them quicker.

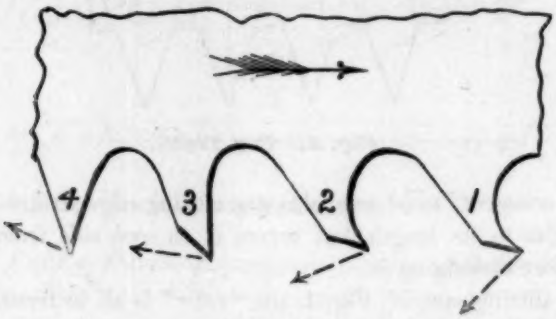


Fig. 6. Showing Various Rakes of Teeth.

Where the teeth are close, the shape of the throat is of special influence.

As regards the tendency of teeth to spring into the work: A form such as Fig. 5, having great front rake, is keen but liable to spring in and break, especially if long and in hard wood. In Fig. 6, tooth 1 has maximum front and minimum back rake. 2 has less hook but more back rake, tending to spring the point down into the wood. 3

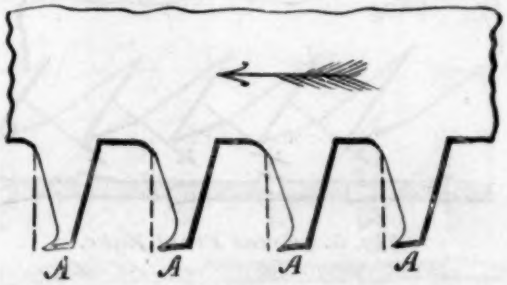


Fig. 7.

has no front rake but considerable back; in 4 the front rake is less than nothing and the keenness is largely dependent on the back edge.

Fig. 7 is recommended for heavy saws for general purposes.

This has a rake to the front of the point, and yet the tendency to spring in is compensated by the backward inclination of the whole tooth; and the cutting edge is well supported. There is ample dust

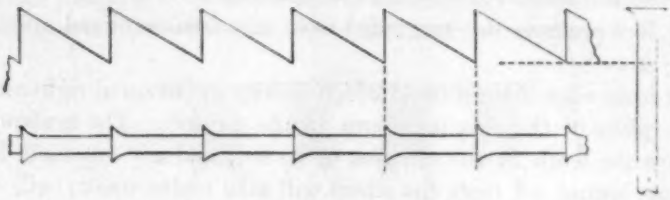


Fig. 8. Spread Set.

room; the rounding corners give strength and immunity from cracking and prevent dust lodging. The backward inclination (as in a planer tool) prevents spring or chatter.

We may now consider briefly the question of *Setting*, or bending the teeth laterally, alternately to the right and left; partly with a view to decreasing friction and increasing clearance, and partly to increase the cutting action of the teeth, and make them *cut* rather than *abrade*. (The earlier nations bent the points of a dozen or so of adjacent teeth to one side, and those of the next group to the other.)

"*Swaging*," is another operation having the same objects—giving clearance, preventing binding and heating, and giving increased keenness to the teeth. In this operation each tooth is upset or widened at its point so as to project beyond the blade at each side; differing in this respect from spring setting. See Fig. 8.

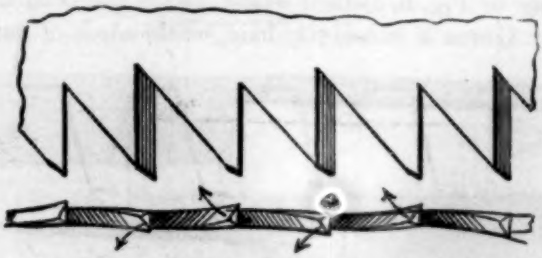


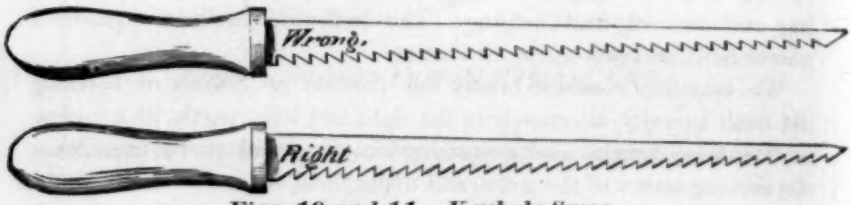
Fig. 9. Spring Set and Side Angle.

Swaging or upsetting is especially beneficial for soft steels and for saws used in soft wood, as it condenses and hardens the metal.

In connection with spring set must be mentioned *side or cross angle;* a bevel or "fleam" given the edges and materially affecting their sharpness and the angle at which they receive the strain of work; as also their retaining their keenness and set.

Fig. 9 represents the magnified teeth of a common hand saw with spring set.

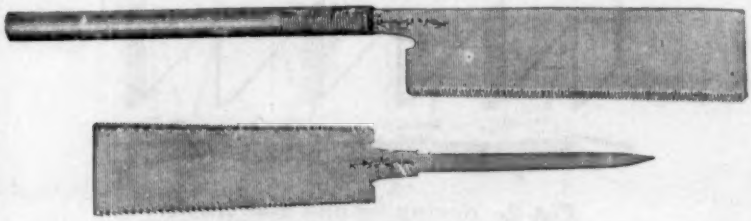
The front edges have a bevel which throws the strain at right angles to the plane of that face (as shown by the arrows). The tendency is to throw the tooth in the *direction* of its set; and any one tooth having more spring set than the others will take undue work; will dull sooner and then spring *away* from its duty, lessening the set and causing friction and heating.



Figs. 10 and 11. Keyhole Saws.

A tooth without fleam or side angle, Fig. 7, has no side strain, other than that due to the spring set. This fleam or cross angle decreases with the thickness of the blade; hence while not fit for heavy saws is proper for hand saws, which, also, have a slow duty. It is better for soft woods, which are free from knots, than for hemlock or spruce, the hard knots of which would break fleamed teeth.

Referring to Fig. 6, tooth 1 would buckle and bend if given any spring set; 3, even if excessively long, would admit of ample.



Figs. 12 and 13. Japanese Saws.

While the teeth remain sharp, spring set tends to increase; when dull, to decrease.

Even setting cannot be over-rated in importance. The tendency of set is to come back. Hence it is sometimes best to first *overset*, then spring back. The setting should not be at a sharp angle but on a *curve*.

Even Swaging is as important as even spring set. A saw with the teeth spread the full width of the kerf will stand more feed than if

Fig. 14. Boynton's M Tooth.

each alternate tooth be bent for the set. Of the fifteen saws tested at the National Sawing Contest at Cincinnati, 1874, we believe that not one was "spring set."

The smaller the saw the greater the advantage of spread over spring set.

The operations of sharpening, setting, and swaging are described in detail in appendices to the present work.

Metals, bone, and hard fine-grained woods, require small teeth with

Fig. 15. Front Edge View, showing two Points of M Tooth dressed to cut in line on one side and two the other

little or no set; ice, and soft coarse-grained woods require them large, widely spaced, acute angled, and much set.

Wet wood is softer and more easily cut than dry, but requires a keener and coarser set saw, giving greater waste. *Gummy and resinous materials* and *ivory* require very keen teeth and slow speed, to avoid the

Fig. 16. Showing Space occupied by M Tooth.

dust being softened and made adhesive—which tendency is lessened by greasing the blade.

Table 1 shows the adaptability of various shapes and sizes of teeth to different work.

As regards the question of *pulling or pushing cut*, those of us who

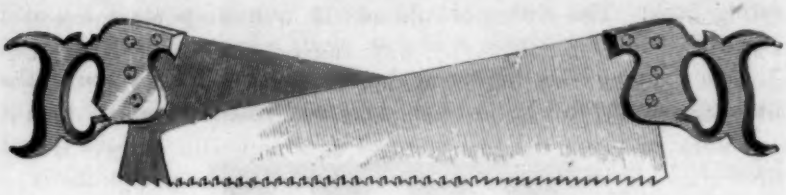


Fig. 17. Double Cutting Action of* M *Tooth Hand Saw.

have smiled—perhaps audibly—at the Japanese with their backward working saws, should bear one thing in mind before condemning *in toto* the pulling cut—that for keyhole or any other flexible-bladed saws, the backward or pulling cut is the best; and our own usage with that exasperating implement the keyhole saw, is much more ludicrous and unphilosophical than the pulling out of the Niphonese.

Figs. 10 and 11* show the common or incorrect, and also the correct mode of placing the teeth of keyhole saws.

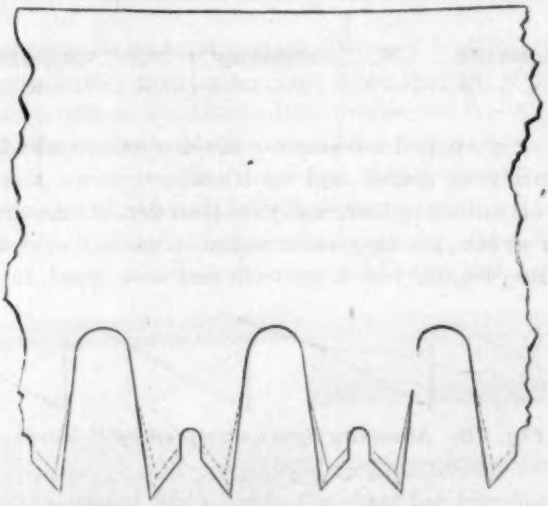


Fig. 18. "Lightning" Teeth.

The Japanese saws are shown in Figs. 12 and 13.

* From *Polytechnic Review.*

The M tooth may be classed among those having no front rake; but ingeniously arranged so as to cut upon *both* strokes. Upon the same base as the ordinary V tooth are erected, in the same line, two teeth, or a double tooth; an M, in fact, with cutting edges fore and aft; its adjacent neighbor being alike M-shaped and sharpened on all edges, but generally both beveled and set oppositely. It may be said to do the same work, and have the same strength, as a tooth with no front rake; but in the same space arranges for a cut precisely as though the saw had been reversed. The M tooth is sometimes expressed as in Fig. 14. As the /\ angle in the ordinary M would be difficult to keep sharp, and ruinous to file-corners, it is now furnished by Boynton with a gullet, making it very economical of files and ensuring keen edges. The M teeth, which are veritable cutting edges, are edged on an oil-stone, after filing. A variation of the M tooth has its front edges raking backward, while it is still a double tooth; and we may style this the "W tooth."

One important feature in the construction of some hand rip saws and mill saws is that they have coarser teeth at the heel than at the point, so that fine teeth commence and coarse ones finish the cut. Fine teeth cut at the outset more smoothly than coarse ones, but as soon as they become clogged with sawdust they lose their efficiency to a great degree. As this partial clogging becomes more troublesome at the latter end of the stroke this "increment tooth" arrangement (similar in principle to the increment-toothed file so favorably known) brings the larger teeth into play just where they are needed, and while obviating the rank tearing of coarse teeth at the commencement of the cut, reduces the amount of splintering at the bottom of the kerf. This arrangement also makes the saw strongest at the heel and lightest at the point. See Fig. 19.

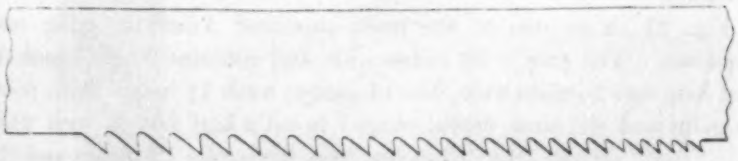


Fig. 19. Andrews' Increment Toothed Mill Saw.

The RECIPROCATING RECTILINEAR saw has many varieties. It may be

(1) strained in a frame or sash, and guided on both strokes, while cutting on one only;

(2) guided at both ends but not strained; pull cut;

(3) free at one end, with pull cut;

(4) free at one end, push cut;

(5) free at one end, cutting on both strokes;

(6) strained in a sash, guided on both strokes, and cutting on both;

(7) unguided at either end; handle at each end, and cutting on one stroke;

(8) unguided at either end; handle at each end, cutting on both strokes;

(9) strained by a weight at one end, cutting on one stroke;

(10) strained by a spring at one end;

(11) strained by a spring frame.

The *Single Sash Saw* is now out of date in this country; being rapidly superseded by the mulay and circular. A mulay with the same power applied will do nearly double the quantity of work, owing to its greater lightness and speed.

A single sash saw will make 150 to 200 strokes per minute and cut about $\frac{3}{4}$ inch in hard and 1 inch in soft wood, at each stroke. It is generally 5 to 9 gauge.

Fig. 20 is a form of mill-saw tooth (Hoe & Co.)

But while the single sash saw cannot compete with the circular in speed of cut or quantity of lumber turned out, the *gang* sash, having several blades strained in one frame, has a greater *collective* speed and capacity; and in the form of the "deal-frame" used in England to resaw squared logs, is one of the most effective of all saws; making little kerf, having a high speed, and cutting many boards simultaneously; while gang-sawed lumber brings a higher price than that from circulars.

Fig. 21 shows one of the most improved American gang sash machines. The sash is 38 inches wide and contains 26 saws each $4\frac{1}{2}$ feet long and 9 inches wide, No. 14 gauge; teeth $1\frac{1}{4}$ inches from point to point and the same depth, swaged to cut a kerf but $\frac{5}{32}$ inch wide. The "cant" is from 10 to 25 inches deep, the stroke 19 inches and the speed 225 revolutions (and consequently full cuts) per minute, at a feed varying from $\frac{3}{8}$ to 1 inch each cut, according to the kind of timber. The machine is run by a double belt 20 inches wide over a driving pulley $4\frac{1}{2}$ feet diameter, requiring an engine of 16 inches bore, 20 inches

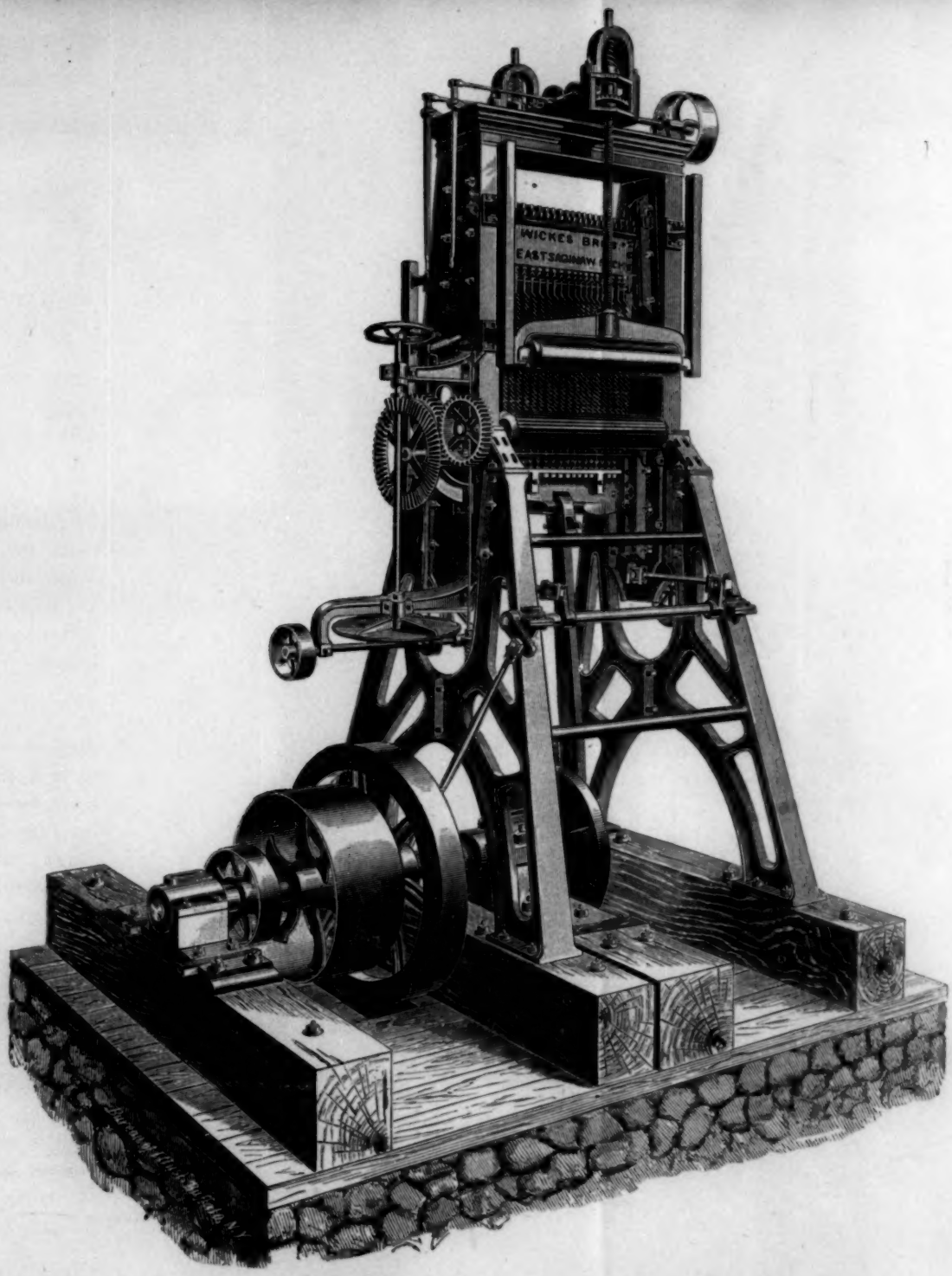


Fig. 21. Wickes Bros.' Iron Frame Gang Sash Saw.

stroke, making 175 revolutions per minute at 60 lbs. pressure. The average capacity is 70 M feet of one inch lumber per day of ten hours —although it may be worked up to 90 M in the same time.

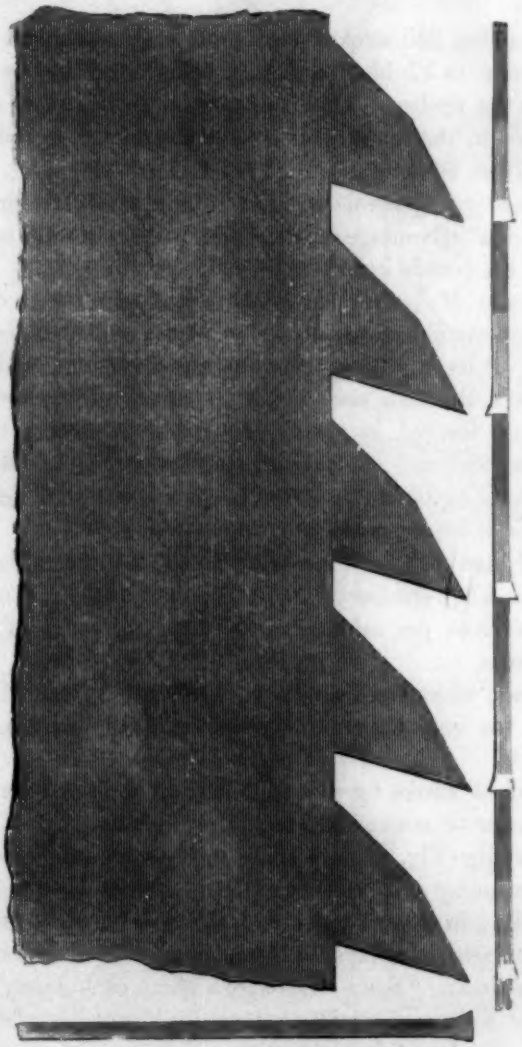


Fig. 20. Mill-Saw Tooth.

The gang sash requires less labor to produce 1000 feet of lumber than the circular does. It works best in connection with a large cir-

cular which slabs the large logs into cants for it. The small logs had best be left to a small circular to saw into boards, scantling or other small timber. This gives the gang continuous work on timber worthy of it.

A gang making 240 strokes per minute will take about $\frac{1}{4}$ to $\frac{3}{4}$ inch feed per stroke in 12 inch cants, *i. e.* from 1 to 3 inches per second, according to the timber. The blades are, as a rule, made narrower at the ends than in the center. They are generally 8, 9 and 10 inches wide, from 10 to 16 gauge.

The thinnest saws possible with a fast gang are fifteen gauge.

The principal advantage of the gang is the extreme regularity in thickness of the boards it makes.

The Mulay or Muley Saw (probably named from the German *Mühl-säge, mill-saw*) comes under the head of blades guided at both ends but unstrained. It has a pull cut and very rapid cutting speed, exceeding in this respect the sash saw, which by reason of the inertia of the frame is more limited in speed. Its use is mainly in the Western States of America; and it is in its inception essentially bold and American. There being but little of the blade exposed unguided, its use at high speed is, however, quite safe.

The mulay saw for logs is generally 10 to 12 inches wide and $\frac{1}{4}$ inch thick, and making strokes of 20 to 24 inches at the rate of from 300 to 400 revolutions per minute, giving a cutting speed of about 600 feet per minute.

Mulay saws, when first introduced, were full $\frac{1}{4}$ inch thick. Now they are in use only $\frac{1}{8}$ inch thick—but generally are No. 7 gauge or $\frac{3}{16}$ inch thick.

The length of stroke for some log-cutting mulays 7 feet long is 28 inches; number of strokes 200 to 225 per minute.

The mulay jig (Fig. 22) is perhaps the best for soft wood.

A "smart mulay saw" making 350 to 400 strokes per minute will cut ordinarily $\frac{5}{8}$ inch hard and $\frac{3}{4}$ inch soft wood at each stroke.

Mulays are almost always the same width heel and point. A correspondent writes: "Some years ago, a party in Auburn, N. Y., took out a patent for a mulay mill that used a tapered saw wider at the top than it was at the bottom, but it was a failure."

Mulay gang and mill saws were formerly made thicker on the front edge than on the back; but for some years past they have been given the same thickness on both edges.

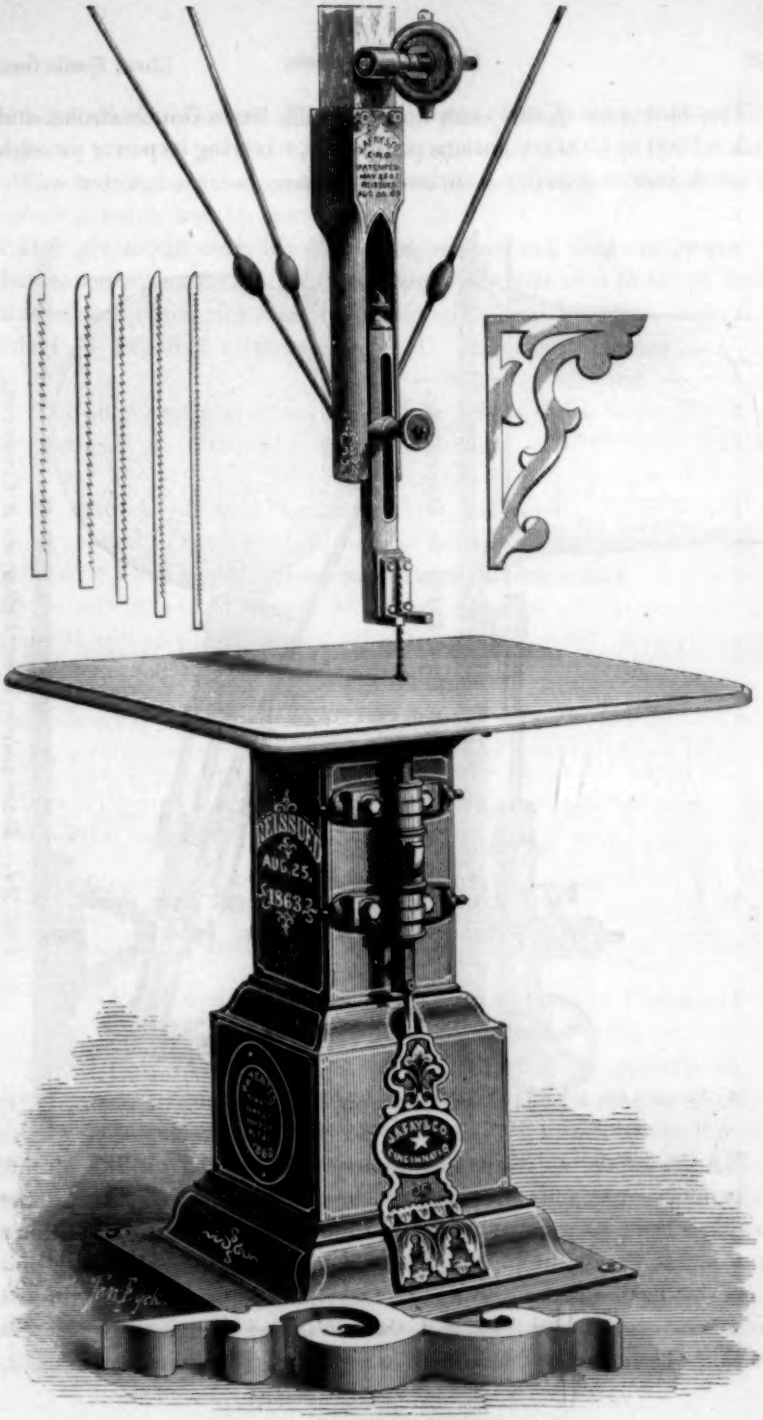


Fig. 22. Fay's Mulay Scroll Saw.

The mulay *scroll* saw shown in Fig. 23 has a 3 inch stroke, and makes 1000 to 1500 revolutions per minute, receiving its power through a 3 inch belt on a pulley 6 inches diameter.

Fig. 23. Ransome's Tree Feller in Operation.

Fig. 24. Ransome's Tree Feller as a Cross-cut.

The Drag Saw, as its name implies, cuts on the pulling stroke. It is unstrained and unguided at the free end; and is, in fact, the Japanese hand saw, power driven and guided at the butt. Its stiffness is of course greater than that of a mulay of the same thickness; and it may be made thinner for the same duty. Its use is mostly limited to cross cutting felled logs and ship timbers; though more recently there has been brought out by A. Ransome & Co., London, England,

an admirable horizontal adaptation of it to felling trees. (Figs. 23 and 24.)

The butting or drag saw is 7 to 8 inches wide at butt, 5 to 6 inches at point, and 10 gauge.

It is given mill teeth if intended to be used as a drag saw proper—that is, cutting on the pull stroke only; but if intended to cut on both strokes, it is given cross-cut teeth.

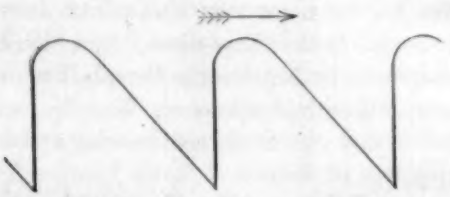


Fig. 25. Drag Saw Teeth for Firewood.

For farmers' use drag saws are 4½ to 6 feet long, and tapered from 7 to 5 inches; stroke 40 to 60 per minute. In shingle mills they are much heavier, and run 80 to 120 strokes per minute; are 5½ to 8 feet long; sometimes tapering from 10 to 6 inches and sometimes 10 to 12 inches wide throughout.

Drag saws for firewood are generally made with a tooth such as shown in Fig. 25. When the cutting is done on the pull stroke, thinner blades may be used than with double cutting saws; but the latter will saw smoother, and are used in drag sawing logs for shingle bolts, because it is desirable to make the edges of shingles as smooth as possible.

Coquillion's Grisoumetre.—This apparatus is designed to show, at all times, whether there is enough fire-damp in a mining shaft or gallery to be dangerous. The report of the engineer's of the Aniche Mining Company states that an experiment of five minutes' duration revealed the presence of one-quarter of one per cent. of the deleterious gas. This remarkable delicacy has attracted the general attention of mining engineers in France and Belgium, Whatever improvements may be made hereafter in the apparatus, the inventor will always be entitled to great credit for his fearless exposure to the dangers of explosion while pursuing his investigations.—*Les Mondes.* C.

CORBIN AND GOODRICH
AND
THE BOILERS OF MR. CAMPBELL.

By W. Barnet Le Van.

The December Journal of the Franklin Institute contains an article on "Steam Boiler Explosions," in which I am referred to as the expert employed by Mr. George Campbell to design boilers for his mill at 21st and Washington avenue.

On page 399 of said Journal, commencing at 14th line from the top, the following will be found:

"We are very glad that he (Mr. Nystrom) has seen fit to refer to his report on the boilers built for Mr. George Campbell, as events have transpired subsequent to that report which show, beyond question, what the result of his inspection led to. The boilers were built by the Baldwin Locomotive Works, according to specifications furnished by Mr. W. Barnet Le Van, who was employed by Mr. Campbell as an expert for that purpose. The boilers were of the type known as horizontal tubular boilers, the lower cylinders being 54 inches in diameter and containing 50 4-inch tubes; the upper cylinders were 30 inches in diameter, and they were connected by two 12-inch necks. When the boilers were finished and our inspectors were called in, preparatory to insurance, it was found that the upper row of tubes in the lower boiler came within 8½ inches of the top. *Allowing for 4 inches of water above the tubes, the surface for disengaging steam was so small that it was apparent to us that nothing could keep the water at an even height, or prevent it from being driven altogether out of the lower boiler at times. We immediately declined to insure the boilers, and so informed Mr. Campbell,* who, naturally desiring further light upon the subject, referred the matter to various experts, and among those so consulted was Mr. Nystrom."

On page 400, fifth line from bottom, and on page 401, is the following:

"Now, what was the result? Encouraged by such teaching as the above, Mr. Campbell was induced to put in two of the boilers at first constructed under Mr. Le Van's specifications, and when they were

fired up the effect was precisely that foretold by our inspector, *and the water, instead of showing a variation of an inch, as stated by Mr. N., a 12-inch glass gauge was not long enough to keep track of it, and no amount of persuasion could keep the water in the lower boiler when fired as originally intended. After several ineffectual attempts to remedy the fatal defects, the boilers were placed in the hands of the Hartford Boiler Insurance Company for such reconstruction as we thought necessary to make them work satisfactorily.*

"*At our direction the Le Van boilers were entirely overhauled,* changing their length to 18 feet instead of 14, and putting in 28 4½-inch tubes, leaving a clear space of 18 inches from top of tubes to shell of boiler. We also enlarged the necks, to save putting a man-hole on the top of the lower boiler. It was at this point that *we stipulated what thickness of material should be used in the necks.*"

Portions of the extracts are printed in italics for the purpose of easy reference.

The following statement sets forth the exact facts in the above matter:

In the fall of 1878 Mr. George Campbell invited me to furnish him with a working drawing of boilers for his mill at 21st and Washington avenue, in this city. The space to receive them at that time was 17 feet in width by 18 feet in length, and the power required was 300 horse power. On plotting, I found that for three boilers the largest diameter that could be employed in the space was 54 inches, and the greatest length 14 feet, and to develop 100 horses through *his* Corliss engine each boiler would require 50 flues four inches in diameter.

Plans were submitted by others in addition to those of myself.

On or about the first of May, 1879, Mr. Campbell informed me he had examined all the plans of boilers submitted, and that Mr. Pike, the inspector of the Hartford Boiler Insurance Company, had examined them, and he had concluded to adopt the plan of boiler furnished by me, and Mr. Campbell requested me to draw up specifications so that he might have estimates for building them, subject to the inspection of Mr. Pike.

Several bids were received from prominent boiler makers, and after accepting my proposition the boilers were ordered to be built by the Baldwin Locomotive Works.

They immediately proceeded to build them, and during their construction the Hartford Boiler Insurance Company were notified, so

that their Mr. Pike might inspect them in detail. Mr. Pike met me at the Baldwin Locomotive Works several times during their construction, and when the first boiler was ready to receive the water test, Mr. Pike was again notified, and was present, as he also was when the first and second boilers were under pressure of both water and steam at Baldwin Locomotive Works.

No objection was made by him up to this time as to material, workmanship or design.

Before the third boiler was ready for a water test, the Wilt & Son's boiler explosion occurred, and the writer was subpœnaed as an expert by the coroner of this city to testify in reference to the cause of this explosion. The boiler at Wilt & Son's mill was insured by the Hartford Boiler Insurance Company, and was under Mr. Pike's inspection.

In July, 1879, the third boiler was finished, and Mr. Pike was again notified to be present, *and at this trial he for the first time informed me that he could not insure these boilers* for (in substance) the following reasons:

1st. That they did not have sufficient outlet from the flue shell of the boiler to the steam drum; that two 12-inch necks were not of sufficient capacity for the proper discharge of the steam generated; that these necks should have been *four* in number, each 12 inch diameter, in place of two as now constructed.

2d. That there was not sufficient surface of water for disengaging of the steam, and that the *water would be driven out of the lower boiler into the steam drum*, and that therefore *they would not be safe to use as at present constructed*, and that before he would consent to *insure them he would insist on the two top rows of flues being taken out.*

This was a complete surprise to me, as no objections to the mode of construction had been made by him or any other person prior to this. I at once consulted with several prominent boiler engineers, none of whom agreed in opinion with Mr. Pike.

After a few days I again met Mr. Pike, and then he informed me he would withdraw his objection in regard to the number of necks if I would increase their diameter to 16 inches in place of 12 inches as now constructed, but he still insisted on the removal of the two top rows of flues as before stated; that he had written to the home office in regard to these boilers, and that Mr. Allen, the President, in reply had left the matter entirely in his discretion to do as he thought fit, and therefore that the above was his ultimatum, as his reputation was

at stake, and that the Company *would rather lose the insurance than take a risk on the boilers as then constructed.*

Mr. Campbell, after hearing the opinion of other engineers coinciding with mine, said he was satisfied, but would like to have them examined on his own account, in which wish I concurred.

He also requested me to furnish him with the names of a number of engineers who were experts in this matter, from which he could select one or two to give him a written opinion, which I did.

From the names so furnished he selected Messrs. Edward Longstreth and John W. Nystrom, and on their written report he ordered the two boilers now finished to be erected.

After being erected the Hartford Boiler Insurance Company's inspector, Mr. Pike, refused to pass them. Mr. John Overn, the City's Boiler Inspector, was then notified and the above facts were related to him and he at once inspected them in person, and authorized Mr. Campbell to have them put in operation.

When first fired up they foamed badly on account of the grease and oil left on their surfaces in the course of manufacture. Foaming occurs more or less in all new boilers.

During their first steaming and from the necessity of keeping the mill in full operation, consequent upon extensive alterations, these boilers were forced over their capacity, as they had at times to drive one-half the work of the mill and the shafting also, the power required to do which was never less than 225 horse-power, and at times 250; whilst the boilers were designed for only 100 horse-power each. This will account for the variation of the water-level referred to.

When the boilers first ordered, were nearly completed Mr. Campbell enlarged the boiler room so that it could then accommodate longer boilers than 14 feet; he also increased the number ordered, first to four, then to five, in place of three as at first contemplated.

During Mr. Campbell's absence from the city the Hartford Boiler Insurance Company induced the Superintendent of the mill to change the other three boilers (one of which was finished but not erected) to 18 feet in length instead of 14, and reduce the number of flues to 28 four and one-half inch flues, by which alteration the power of the boilers was reduced 20 per cent., and also to increase the diameter of the necks to 16 inches diameter in place of 12 inches, thereby decreasing the strength of the boilers about 25 per cent.

When the Superintendent directed a change to be made in the third

and fourth boilers, which were completed but not erected in brick work, I protested, but without avail. Directions having been given to make the change, I then desired that the necks should be made of metal one-half inch thick, in order to compensate for the decrease of strength caused by cutting holes 18 inches in diameter for the accommodating of the larger necks ordered to be put in. This was consented to by Mr. Pike and the Superintendent of the mill at the time the order was given to the Baldwin Locomotive Works. The next morning Mr. Pike called at Baldwin's and *changed* the order from *one-half inch in thickness for the necks to three-eighths in thickness*, stating that if *half inch* in thickness was used he would not insure the boilers.

This alteration of the order I was not aware of until several days had elapsed; the plates had been ordered by telegraph to be made at the Otis Steel Works, Cleveland, Ohio, and were probably completed.

The assertions made by Corbin and Goodrich, Agents of Hartford Boiler Insurance Company, in their communication in the December number of the JOURNAL OF THE FRANKLIN INSTITUTE, herein quoted from pages 399, 400 and 401, are not true, and are calculated to injure the writer by the false impressions they tend to produce, making it proper for me to set forth the facts as they actually occurred.

The two boilers first built were constructed *in exact accordance with my designs, and without any alterations;* they were set in brick work in the boiler room in the mill, and then fired up and put into service. *These boilers are still in service*, and have been since September 5th, 1879, *unchanged in construction, and giving entire satisfaction.*

Moreover, I have been informed by Mr. Campbell that *they have been recently insured* by the Hartford Boiler Insurance Company, notwithstanding the statements that have been published by that company in this journal.

Furthermore, I have been informed by the engineer of Mr. Campbell, in the presence of Mr. John Overn (Chief Boiler Inspector of this City) and of Mr. Edward Longstreth, of the Baldwin Locomotive Works, that he had no trouble whatever in maintaining a steady water-level in these boilers, and that when the engine was stopped suddenly the water never fell in the glass water gauge over *one inch.*

To-day, December 24th, 1879, I met Mr. Pike at Mr. Campbell's mill, and he corroborated Mr. Campbell's statement in regard to insur-

ing the two first boilers erected by me, and which they had at first refused to insure.

In conclusion, I desire to call attention to the quotations from the December JOURNAL, which I have italicized, and to show the inconsistency of the statements of the agents of the Hartford Boiler Insurance Company, regarding the boilers in question, with the action of the company in insuring the same.

THE WIRE BOOK SEWING MACHINE.

By H. BILGRAM, M.E.

Read before the Franklin Institute at its meeting, October 15th, 1879.

The most important step forward that has lately been made in book binding is undoubtedly the substitution of wire for thread. A machine for sewing books with wire was recently exhibited at a meeting of the Franklin Institute, where several books were sewed before the audience.

The principle of this machine consists in producing a number of U-shaped wire staples, which are driven *from the inside* of each section of the book through the back and through one wide or several narrow bands of a strong linen or cotton fabric, whereupon the ends projecting through the back are clinched over, and thus a firm connection between the sheets of the section themselves and the band or bands covering the back of the book is produced. The machine fastens a section at each revolution of the main shaft, and can be run at 40 to 43 revolutions per minute. The book sections are fed by the operator, partly opened, upon a table which, by an oscillating motion, brings the sheet in position to be sewed. By an adjustable downward feed of the table on which the book is sewed, the sections can be sewed tight or loose, to suit the degree of "backing" in the subsequent forwarding of the book.

The principal merits of this mode of binding books are strength, durability and flexibility, besides the saving of labor, as an operator can turn out as much work on one of these machines as from five to eight operators can do by hand. Greater strength is given by the several sheets of each section being clamped firmly between the back and the clinched legs of the wire staple while the thread in thread-

sewed books holds the centre sheet only by the edges of the cuts through which the thread passes. If the inner sheet of any section of a thread-bound book be torn out by force, the thread cuts its way through the fold of the sheet; while in a wire-sewed book the sheet will tear in a double line, leaving a small strip of paper underneath the wire staple. This simple test proves at once the superior strength of a wire-sewed book.

The firmness of a wire-sewed book is not so much dependent on the gluing of the back as is the case with a thread-bound book. The inner sheet of any thread-bound book is held in position by the glue in the several saw-cuts; for if this connection is carefully severed without injuring the thread connection, the sheet can be moved up and down as much as the thirty-second of an inch, while nothing short of actual tearing of the paper can make the corresponding sheet of a wire-sewed book move through the same distance.

Rusting of the iron wire is effectually guarded against by tinning it.

Increased flexibility is insured by the diminished thickness of the flexible back of the book. In the old way of binding, the flexible connection of the several sections of the book is represented by two or more comparatively thick strands laid in the saw-cuts on the back of the book, and held there by the thread passing round them; while on the wire-sewed books the corresponding connection extends over the greater part of the back, and is not only much thinner and more flexible, but also much stronger. The book opens very freely indeed.

In binding the first books sewed with wire, some difficulty was experienced in the wires thickening the back of the book so much that in pressing it for the purpose of cutting, the paper was crushed by the wire just where it should have been strongest. This defect has been overcome by inserting the staples in a zigzag line, so that there appear two or three times as many rows of staples on the back as there are staples in each section.

In Europe these machines have been introduced with a remarkable rapidity, there being now about 150 of them in successful operation in England, Germany, France, Belgium, etc. Both the United States and the English Government binderies have adopted them, and thereby considerably reduced the cost of binding, besides producing superior work. Especially for the manufacture of blank books is this mode of binding superior, as is shown by the fact that in Germany hand-sewed books are sold at a discount in order to compete with the wire-sewed work.

On the METHOD of MILK SHIPMENT in GLASS JARS.

By J. Cheston Morris, M. D.

Read before the Franklin Institute at its meeting Dec. 17th, 1879.

No more important subject can engage the attention of a community than that of the purity and abundance of its food supply, and no one article of food is of more importance to every class in the community than that to which I wish to direct your thoughts for a few moments this evening, constituting in some form an essential ingredient in the food of almost every one, from the cradle to the grave. Even among savages its value is appreciated; and as men rise in civilization we find them more and more dependent upon it and using it in more various methods. The natural food of all young mammalia, it still constitutes the best and most available form of nutriment in health and disease. How important, then, that it should be as fresh, pure, and rich as possible. Here, however, comes the difficulty. It is perishable, quickly prone to change and very susceptible of becoming tainted by contact with impure substances—nay, even of becoming the vehicle through which organic poisons, such as that which produces typhoid fever, may be disseminated according to some authorities. And the difficulty increases with the size of a community, which involves increased distance from the source of production and renders it necessary that it should pass through one or more hands between the producer and the consumer. In the sharp competition of trade this renders it liable to adulteration as well as to the certain deterioration which ensues upon the loss of time in transit. No wonder then that the article which in town we know as "milk" is so different from that we find in a country spring-house. I do not mean that good milk is not, very often, delivered by the milkmen in Philadelphia; on the contrary, I believe that our milk supply here will contrast favorably with that of most other large cities. But there is room for improvement—in many cases a great deal of room—and it is much to be desired that any means to affect this should be made known as widely as possible. Having been engaged practically and, I may add, successfully in an effort toward this for more than a year, I wish to lay my method before you, and thus contribute my mite for the public good.

The cows at my farm, near Westchester, are all pure Devons, and are fed on good nutritious food—hay, bran, corn meal, potatoes, beets, or ruta-bagas—and are well housed, so as to maintain them in good health. Their udders are carefully washed before they are milked. The milk, as soon as drawn, is strained into a 40 quart can, in the centre of which is suspended a 10 quart can containing a freezing mixture of ice and salt, so as to reduce the temperature as rapidly as possible to 50°F. When the thermometer shows this to have been accomplished (which will require 15 to 20 minutes) the milk is drawn off by a faucet into quart jars (I use the Cohansey fruit jar, as being convenient and meeting all requirements), and each jar is closed and sealed with a label bearing the name and address of the producer, date of shipment, and quality of the milk. This label (a slip of paper pasted or gummed) cannot be removed or tampered with in transit without destroying it. Twenty of these jars are packed in a box, and are ready for shipment and delivery to customers. In warm weather one jar in the middle is filled with ice. The milk may be kept in them until required for use. The empty jars are to be rinsed and returned when fresh ones are delivered. The advantages of this method are as follows:

1. The milk must be clean, as any dirt would show at the bottom of the jar.

2. It is free from contamination by foul air, etc., in transit. This is a very important advantage, as any one can appreciate who has happened to enter an ordinary milk car and noticed the foul putrescent odor which results from the slopping of milk over the car floor, when it soaks in and undergoes decomposition.

3. Each quart of milk contains its own share—no more, no less—of cream. When 40 quarts are sent, as is usually the case, in a "churn," the cream soon rises to the upper part, and the abstraction of more or less cream from the milk is easy. To obviate this the milkman may frequently be seen stirring up the contents of his can, but it may readily be surmised that favorite customers may receive some share of cream that properly belongs to others less fortunate.

4. If the jars have been properly filled no "churning" is possible. In the ordinary method more or less churning is apt to take place.

5. The consumer can be sure that he gets the real article furnished by the producer.

6. It is the interest of the producer to send the best article he pos-

sibly can, as the price he will receive depends upon it, and consumers will not be slow to show their appreciation of his merit or demerit. In the ordinary mode this is not the case. Milk is milk, and the man who really and honestly tries to send the *whole* produce of his herd finds he receives no more for it than his dishonest neighbor who removes part of the cream, or adds a little water.

The average yield of a good cow may be estimated at 2400 quarts per annum, or between 6½ and 7 quarts daily. At the usual prices of corn, hay, etc., the cost of keeping would be nearly 30 cents daily. The cost of production, therefore, is not less than 4½ to 5 cents per quart. It will readily be seen that when the risks and cost of transportation are considered the farmer does not make a large profit, even if he gets his fair proportion of the 8 or 10 cents per quart, which are the ruling prices—the former in summer, the latter in winter. But even this he does not get, as the price of milk at the railroad depots is 2½ cents in summer and 4 cents in winter. Of course somebody suffers for this.

To return to the quality of milk, and especially to the variation which occurs in different breeds.

The *Durham*, or short-horn cow, yields a large quantity of milk, rich in casein but poor in butter and sugar. The ordinary or "common" cow is largely "grade Durham," and may be classed under the same head. Rather richer in butter and less watery is the yield of the *Holstein* or Dutch cow, a variety of the short-horn class. Next comes the *Ayrshires*, a very useful class.

The *Jerseys*, or Alderneys, yield a comparatively small quantity of milk, very rich in butter but poor in cheese and sugar; hence when the cream is removed there is only a very poor skim milk left. These animals are not fit for dairy cows for milk purposes. But "grade" Jerseys yield abundantly a good article.

The *Devon* cow stands intermediate between the Durham and Jersey as to amount of yield and percentage of butter, but yields a milk richer in sugar than any other, and hence better adapted for general use, more nutritive and palatable.

As to the sort of glass jar required, it should have a large opening, so as to be cleansed readily; it should be capable of being completely filled, and should be easily closed and opened. Any jar fulfilling these conditions may be used. After I had used the Cohansey for six months I saw Mr. Lester's jar, which is good but cumbrous. That

used by Mr. F. Ratchford Starr of New York, as well as the bottles employed by M. D'Arcy in Paris, seem to me not so convenient, on account of the narrowness of the mouth; cream could not be taken separately from them so readily.

The importance of this branch of trade may be estimated when it is known that the milk supply of Philadelphia is nearly 150,000 quarts daily, costing the consumers, at eight cents per quart, nearly $12,000, or annually about $4,376,000. And yet the quantity daily consumed by each individual, supposing the population of Philadelphia to be 850,000, is less than one-third of a pint for each man, woman and child. This is rather more than the average of England, though less than half that of Wales, and not one-third of that of Scotland or Ireland.

The nutritive value of milk is hardly sufficiently appreciated by us. According to the best and most recent analyses, good milk contains, in each quart:

Butter,	543·3 grains,	or nearly	1¼	oz. avoirdupois.
Casein,	1026·3 "	" more than	2¼	" "
Milk-sugar,	452·8 "	" " "	1	" "
Salts (phosphates, etc.),	90·6 "	" nearly	⅓	" "

Two quarts, therefore, of milk, with 12 oz. of bread, contain sufficient nutriment for a laboring man daily—more than the French cavalry ration. No cheaper food of equal nutritive value and easy assimilation can be found.

The Satellites of Mars.—On the 10th of October Prof. Hall found Deimos, the outer satellite, almost precisely in the calculated position. The place of Phobus was not predicted so accurately, because its proximity to Mars made observations more difficult, and some of the auxiliary estimates were calculated for the orbital plane of Deimos. But these difficulties have exerted only a very slight influence on the results. Both positions are within the limits of probable error, which were announced by the discoveries in 1877. The 2443 intervening revolutions of Phobus require a diminution of only 1·074 sec. in the predicted time, showing an error of less than $\frac{1}{2\,7\,5}$ of one per cent.! A very careful and exact reduction of observations will be necessary in order to determine whether any correction is needed in the elements of Deimos.—*Comptes Rendus.* C.

A NEW ILLUSTRATION OF "PERSISTENCE OF VISION."

By PROF. SILVANUS P. THOMPSON.

A friend has called my attention to an article in the November number of your Journal, by Professor T. W. Tobin, bearing the above heading, and treating of some curious optical illusions discovered by me about three years ago. A quotation is given by Professor Tobin, I know not from what source, which certainly was not written by me, and concerning which I beg to make the following remark:

I have always maintained that the illusion was due in part to the "persistence of vision." For eighteen months the published sets of cards have been before the public, and the printed description which accompanies each packet runs as follows: "This new and interesting Optical Illusion depends upon the well-known scientific principle of the Persistence of Vision, namely, that an object placed only for an instant before the eye is seen for an appreciable time after its removal, its image remaining about the eighth of a second on the retina of the eye. If the card be held between the finger and thumb, and moved rapidly in circles with a slight motion of the wrist, the circles will appear to rotate on the card."

At the same time I have always maintained that persistence of visual

impressions failed to account for several of the phenomena accompanying the illusion. In the first place, I find that there is a particular distance from the eye which suits best a set of circles of a particular size. Very numerous and narrow circles exhibit the "rotation" excellently when held at a few inches from the eye, but at three feet distance quite fail; whereas a set of circles in which the alternate rings of black and white are three inches in width from ring to ring do not show the effect at all a foot away, but show it capitally to an audience of a hundred persons. Apparently, to obtain the best result, the width of ring must be proportional to the distance from which it is to be viewed.

Again, if some of the "circles" are lying on the table in view, while a set are being "rotated" by hand, those lying on the table will seem to rotate, though the eye is looking at the moving "circles." This observation, like the preceding, is absolutely inexplicable without recourse to some further hypothesis than that of the *persistence of visual impressions*. Moreover, the illusions succeed best if the eye be directed not at the circles themselves but at some point near. For this reason I have found it best to have *two* sets of circles printed side by side on the card; that set rotating most effectively at which the eye is *not* directed.

As to Professor Tobins's elegant demonstration that the successive displacements of a circle around its centre are optically equivalent to the eccentric rotation of the circle itself about some central point, it is deductively perfect; only it falls short where the theory of persistence of vision in general falls short, and cannot afford the complete explanation of the other phenomena I have described.

I may perhaps mention, in conclusion, that M. Duboscq, of Paris, has recently constructed for me a little piece of apparatus which enables me to project the circles upon the screen on a large enough scale for an audience of a thousand persons to witness the illusion at one time.

University College, Bristol, England, Dec. 12, 1879.

Bessemer Steel in Europe and America.—The production of Bessemer steel, since 1870, has advanced from 40,000 tons to 550,000 tons in the United States, and from 250,000 to 750,000 tons in England. Germany and France each produce about 250,000 tons, and the rest of Europe about 200,000 tons.—*Rev. de Engeuh.* C.

VELOCITY OF LIGHT.

By Pliny Earle Chase, LL.D.

The late experiments of Michelson, and those upon which Newcomb is now engaged, may lend interest to approximations to the velocity of light by the nebular hypothesis.

On the 24th inst., I found the first of the values which I give, in connection with other recent estimates, in the following comparative table. The only elements required in the calculation are, the force of gravity at the equator, the diameter of the earth, and the lengths of the terrestrial day and year.

I have found, to-day, the second value, which I am inclined to regard as still more accurate.

Light requires 497·827 seconds to come from the sun to the earth, a distance of 214·54 solar radii. If planetary revolution were possible at sun's surface, the velocity $\sqrt{gr}$ would be ·00062563 r per second, or $\frac{1}{688.84}$ as great as the velocity of light. The solar *modulus* of light, M, is therefore 474,500 r. According to Stockwell, the centre of the dense belt of planets, or the primitive centre of greatest condensation, C, is at 1·016878 earth's mean radius vector, or at 218·16 r. From the necessary action and reaction between the nucleal centre and the principal centre of condensation I deduce the equation,

$$\left(M \times C\right)^{\frac{1}{2}} = \frac{1 \text{ yr.}}{1 \text{ dy.}} \times \frac{g^{\circ}}{g'}$$

From this equation we readily find 27·78 for the quotient of solar by terrestrial equatorial gravity, $\frac{g^{\circ}}{g'}$, and 185,852 miles, or 299,090 kilometres, for the velocity of light per second.

	Velocity of Light.		Neptune, sec. perihelion.
Foucault,	298,000 km.	Leverrier,	29·602
Cornu,	300,000 "	Stockwell,	29·598
Perry and Ayrton,	298,000 "	Newcomb,	29·619
Michelson,	299,820 "	Chase,	29·608
Chase, 1,	298,030 "		
" 2,	299,090 "		

In the estimates of Neptune's secular perihelion, I have adopted Stockwell's value for the greatest secular eccentricity, ·0145.

Haverford College, *Dec. 29th*, 1879.

IRON BRIDGES.

When the public was startled by the fall of the St. Charles bridge, it derived much consolation from the fact that only a freight train was engulfed by the catastrophe. Scarcely has the public ceased to congratulate itself over the small loss of life attending the failure of that splendid structure, when the cable flashes from England the intelligence that another great railroad bridge has gone down, and furnished a fearful example of what might have been, had the St. Charles bridge succumbed to a passenger train.

The longest railroad bridge in the world, over running water, is the bridge over the river Tay, in Scotland. It is 10,612 feet in length, or 52 feet more than two miles. It consists of 85 spans, of varying extent, eleven of them having a length of 245 feet each. It is an iron truss, and at its opening, in May, 1868, it was subjected to the most rigid tests, and was pronounced a great triumph of engineering skill. English engineers have envied their American brethren because the latter have, of late years, so greatly surpassed them in the construction of iron bridges. As an English engineer put it, "Nature has especially favored the Americans in giving them great rivers to cross." When, therefore, this magnificent bridge across the Firth of Tay was pronounced finished, and was opened with imposing ceremonies, English engineers congratulated themselves that their island had at least one structure which would rank with the most noted American examples. But this pride of English engineering has succumbed in the midst of a hurricane, and an entire train containing more than 200 passengers plunged into the water beneath it, and not a single reservoir is left to furnish materials for a plausible theory of the accident. The eleven large spans are reported to have disappeared, leaving only the naked iron piers on which they had rested. It is the most appalling railroad accident that has ever occurred. Three hundred travelers left their homes that day forever, and were never more unsuspicious of danger than at the moment before they plunged into eternity. The suddenness of their fate and the horrid completeness of their taking off are too terrible to dwell upon.

Will the cause of this fearful disaster ever be known? is a question now of very great importance. Are the failures of such bridges as

the St. Charles and Tay the result of inherent defects of construction, or must they be ascribed to accidental causes, which can be surmised but not demonstrated? Although the bridge builder's art is very old, he is now exercising it under new conditions. The advent of the locomotive calls for the exercise of his powers on a scale never before known. The old methods of travel admitted of such devices as fords and ferries in the passage of streams, but the iron horse will have none of them. Whenever he approaches a river he imperiously demands a bridge, and he does not leave the engineer much choice of crossings. Wherever traffic seems to point out a pathway, there he must go, and no matter what difficulties lie in the way, they must be surmounted. The largest rivers are not allowed to bar his progress, and giant streams, which, but for him, would have been ferried over for ages, must now be spanned by structures superior in strength to any heretofore known. Hence, although the bridge builder's art has the perfection which comes of long practice, the locomotive is severely taxing his resources.

Bridge-building, like civilized man himself, has had its three ages. First, came the age of wood, then followed the age of stone, and lastly the present wonderful iron age. The use of iron in bridge construction has produced a boldness of conception in the present generation of engineers which casts the performances of their predecessors entirely in the shade. A half century ago such spans as the fallen ones of the St. Charles and Tay bridges, for such loads as they were calculated to support, were impossible. Now they are far from being of the first magnitude. There are ten truss bridges across the Mississippi above St. Louis, which are not regarded as very wonderful structures, and yet seven of them have spans as long as those of the Tay bridge. The bridges at Winona, LaCrosse, Dubuque, Keokuk and Hannibal have spans of 240, that at Rock Island of 250, and that at Louisiana of 256 feet. The span which gave way at St. Charles was 320 feet in length, yet the same bridge has two spans 406 feet long. Over the same river is a truss bridge, at Leavenworth, with three spans 340 feet, and another at Glascow with five of 315 feet. Across the Ohio there is a truss bridge, at Steubenville, with a span of 320 feet, one at Parkersburg of 350, one at Cincinnati with a span of 515 feet, the longest truss yet built, and one at Louisville with a span of 400 feet. The truss bridge over the Kentucky river, on the Cincinnati and Southern Railroad, has three spans 375 feet in length resting

on iron piers 175 feet high. The bridge over the Hudson, at Poughkeepsie, has five spans of 500 feet, with piers 135 feet above high water. In Europe there is a truss bridge over the Vistula, at Graudenz, with 12 spans of 300 feet. The truss bridge of Lessart, in France, has a span of 314 feet, and was pushed across from one abutment to the other after being put together. The bridge over the Rhine, at Wesel, has four spans of 313 feet. The Kulenburg bridge, in Holland, which was the monarch truss before the construction of the Cincinnati bridge, has a span of 492 feet. From these examples it would seem that the St. Charles and Tay bridges, instead of being risky engineering ventures, are entirely within the domain of experience. But, nevertheless, the fact remains that, notwithstanding the boldness with which the engineers of the present day meet the exactions of the locomotive, they are comparatively novices in the use of iron. The first iron bridges were of cast iron, and soon proved to be too lightly proportioned. The first suspension bridges were similarly defective. Does it remain to be proved that the wrought iron work of the past twenty years betrays too great a confidence in the material? Were the St. Charles and Tay disasters unaccountable accidents, or were they fair tests of current engineering theories? These are questions which engineers would do well to discuss.—*St. Louis Globe Democrat.*

Pictet's Calorific Syntheses.—Pictet modifies Mossotti's hypothesis, by supposing that atoms attract each other as well as attracting ether. He regards the gaseous atom as simple, the liquid molecule as composed of at least two gaseous atoms, and the solid molecule as containing at least two liquid molecules. Starting from the amplitude of calorific oscillation, he explains, by simple mechanical laws, the law of Mariotte and Gay Lussac, the anomalies with their limits and the conditions of passage from the gaseous to the liquid state, the mobility of liquids, their feeble compressibility, their diffusion and volatilization; the rigidity, elasticity, hardness, axes of crystallization, allotropism and amorphism of solids; the absolute zero temperature, thermic equilibrium and specific heat of bodies; the law of Dulong and Petit; fusion, evaporation, latent heat, density, vapor-tension, and nearly all the phenomena of thermo-chemistry. He thinks it probable that the dimensions of atoms and molecules may be deduced from his experiments.—*Bull. de la Soc. Vaud.* C.

ELECTRIC LIGHTING AT THE BRITISH MUSEUM.

When the electric light was first pronounced to be a practical success, the authorities of the British Museum resolved to give the frequenters of the reading-room the advantage of that method of illumination during the hours of darkness and fog which so frequently prevail at certain seasons of the year. Accordingly last autumn, as our readers will remember, the reading-room was lighted by the Jablochkoff system, which, so far as it went, is stated to have given every satisfaction. Being desirous of giving each practical system a fair trial, the authorities of the Museum have this year adopted experimentally the Siemens system of electric lighting, which was exhibited last evening for the first time to a select party of scientific gentlemen and others interested in the question.

The proposals for lighting up the reading-room by this system were originally submitted by Mr. J. J. Calder and Mr. J. A. Barrett, and the arrangements were finally carried out under the superintendence of Mr. Barrett, who is the electrician for the Museum. Eleven lights in all have been fitted up, and of these four are placed in the reading-room, four in other parts of the building, and three outside of it. The four in the reading-room are placed, one in the centre and three equidistantly around it. They are supplied with continuous currents, each from its own Siemens dynamo-electric machine. Of the lights in other parts of the Museum, two are placed in the entrance-hall, one in the reading-room corridor and one in the Greek gallery. In the courtyard in front of the building are two more lights, while another is placed in the rear, near to the engine and machine house. These seven lights are supplied from one Siemens machine, producing an alternating, or divided current. It will thus be seen that two different systems of electric lighting are employed, both, however, being on the Siemens principle—the four lights in the reading-room being produced by continuous currents, and calculated to be each equal to 4000 candles, the seven other lights, which are estimated at 400 candles each, being produced by an alternating current, and being connected in one circuit about 1200 yards in length.

The lamps in the reading-room are governed by regulators, which are the invention of Messrs. Siemens and Halske, of Berlin. These

regulators are of very simple construction, and consequently can be managed without any special electrical knowledge. The carbons are 19 inches in length, and their rate of consumption is about three inches per hour, so that the light can be maintained for six hours without touching the regulators. The lights produced by the alternating current are fitted with a different kind of regulator. These regulators are actuated by two solenoids on a differential principle. One solenoid forms part of the main circuit and tends to separate the carbons, while the other forms a shunt round the carbons and tends to bring them together. The position of the carbons depends, therefore, not on the strength of the current, but on the relative amount of electricity passing through each solenoid. By selecting suitable resistances for each coil an arc of a given resistance will always be maintained, independently of the strength of the current. This obviates the necessity for regulating the lamps after they have left the hands of the makers. The arrangement of these regulators is such that should one light in the circuit become extinguished, the others will not be in any way affected. The carbons in these lamps burn for about five hours and can be replaced in about a minute. The lights in the reading-room are suspended from the roof, and are enclosed in octagonal lanterns, filled in with ground glass, and having circular reflectors placed over them. The other lights in the building and that at the engine-house are also suspended, while the two in the fore court are placed on standards. They are all enclosed in ground glass globes.

The machines for producing the currents are six in number, and are placed in a small house to the rear of the Museum. Of these, four are the continuous current machines for supplying the four lights in the reading-room; one is the alternate current machine for supplying the other lights, while the sixth is used as an exciter for all the rest. The leading wires from the machines to the lights in the reading-room are carried over the roof of the building to the lantern on the top of the dome, a distance of about 200 yards. The wires for the other lights are laid partly in the basement of the Museum and partly underground. The motive power for driving the machines is supplied by two 8-horse semi-fixed engines by Messrs. Wallis & Stevens, of Basingstoke. These engines embody several special features, which render them particularly applicable for driving machinery for generating electricity for lighting purposes, foremost among which is perfect regularity of speed, which is maintained by a special kind of governor. The maintenance

of an uniform speed is of the first importance in electric lighting, inasmuch as any slight variation in the engine causes irregularity in the light and vitiates the results. The power is transmitted to the electric machines through belts and shafting, and the whole arrangement during our visit worked steadily and well. The revolutions of the engine were 125 per minute, and the steam pressure about 60 pounds per square inch. On the whole, the experiment was perfectly successful, an excellent and agreeable light being produced and maintained. A slight unsteadiness was apparent at times in some of the lamps, but this was stated to be due to defective carbons. This reason is so frequently assigned for aberrations of various electric lighting systems that it would be as well if carbon manufacturers would set to work to produce carbons of perfectly uniform quality, and thus get rid of this drawback to electric lighting.—*London Times.*

Superficial Viscosity of Liquids.—In the course of his experiments upon the equilibrium of liquid masses without weight, Plateau found that some liquids showed a special resistance at their surfaces while others were more viscous in the interior. The difference may be studied in the following manner. Place a magnetic needle on a pivot in a cylindrical glass vessel; pour in the liquid until it reaches the lower surface of the needle; turn the needle 90° from the magnetic meridian, then release it and notice the time occupied in traversing a specific angle. In his experiments the angle was 85°. Then add more liquid, so as to completely submerge the needle to a depth of about 2 centimetres (·79 in.), turn the needle 90° and note the angular time as before. For distilled water, the time in the first experiment was nearly twice as great as in the second, though in the former case the friction against the water was only on one surface, while in the latter it was on both surfaces of the needle. In spirits of turpentine or in alcohol, the time on the surface was less than half as great as in the interior. A solution of albumen and a solution of saponine had remarkable superficial viscosity. On the surface of the former, the needle stopped after slowly turning an angle of 35°; on the surface of the latter it did not even begin to move. Luvini and Maranzoni have attempted to controvert Plateau's views, but he has shown in what respects their experiments were defective.—*Bull. de l'Acad. de Belg.* C.

Irrigation by the Tagus.—A proposal has been laid before the Portuguese Government to build a dam across the river Tagus, about 20 km. (12·43 miles) above Abrantas, in order to raise the level sufficiently to irrigate about 400,000 trucus (988,657 acres) of the adjoining lands. The expense would be very small in comparison with the increased value of the land, which is estimated at 600,000,000 francs ($120,000,000), or nearly one-third of the Portuguese national debt. —*Chron. Industr.* C.

African Railway.—Duponchel's projected railway for connecting Algeria with Soudan continues to excite great interest in France. A commission of 65 members has been appointed, and divided into four sub-commissions. The first, under the presidency of de Lesseps, is to collect statistical and economical information; the second, under Duponchel, is devoted to technical studies and the determination of routes; the third is to have charge of the explorations, and the fourth will consider international questions, especially with reference to the Moors, the Tripolitans and the Toncuezs. Many of the senators and deputies, who are members of the commission, have visited Algeria in order to understand the different projects which are to be brought before them.—*Les Mondes.* C.

Precautions in Comparing Weights.—Deville and Mascart, in explaining the construction of the international geodetic standard, give an interesting account of some of the necessary precautions: During the long series of operations upon which a comparison of two weights is based, a balance should never be opened. Its cage, composed of two envelopes of glass, bordered with cloth, should be guarded from the external air, which would change the hygrometric state of the interior, and which would introduce dust. The particles of dust notch the knife-edges, and change the velvet linings of the weight-boxes into a material comparable to emery-paper. Air may be forced into the interior, at the rate of 4 or 5 litres (4·227 or 5·283 qts.) per hour, being first deprived of dust by filtration through cotton, and dried by chloride of potassium or other dessicatives. The substance which seems to produce the least wear on alloys of platinum and iridium is ivory, which has the further advantage of resisting moisture and other atmospheric influences, as is shown by cave fossils. The standard weights should, therefore, be kept in glass cylinders, with ivory caps at top and bottom.—*Comptes Rendus.* C.

Electrical Phenomenon at Potenza.—Cappanera finds that natural electric currents often traverse the telegraphic wires, which are strongest in the neighborhood of the volcanic terrace of Vultures. They are most noticeable in October, November, December, March and April, especially during falls of snow.—*Bull. del Vulc. Ital.* C.

Biermann's Wolfram-bronzes.—Biermann, in Hannover, furnishes a Wolfram-bronze which contains, according to Strohmeyer, 95·39 per cent. of copper, 3·04 per cent. of tin, 1·57 per cent. of wolfram. It is very tough, malleable, ductile, and of great absolute strength. An addition of from 1·5 to 2 per cent. of wolfram increases the hardness four or five-fold, without diminishing the toughness. The bronze requires, for working, a temperature 100° higher (180°F.) than ordinary brass, and can only be cast in very dry sand or in iron moulds.—*Berg- u. Hütten-Ztg.* C.

On Uralium, a New Metal of the Platinum Group. A. Guyard.—As far back as 1869 the author discovered this metal in commercial platinum obtained from Russian ores. Next to silver it is the whitest metal known; its malleability is as great as that of the purest platinum, but its ductility is much greater, and it is almost as soft as lead. Its melting point lies near to that of platinum, and it is not volatile. Its specific gravity is 20·25, and its molecular volume, like those of osmium, platinum and palladium, is 6·25. Its atomic weight has been found to be 187·25. In its chemical properties it is difficult to distinguish from platinum.—*Chem. News.*

New Element.—Tellef Dahll has found a new element, which he calls *norwegium* (Ng.), in a compound of arseniuret of nickel and nickel glance. It is white, somewhat malleable, of copper-like hardness, melting at a red heat, density 9·44. It dissolves with difficulty in hydrochloric acid or sulphuric acid, easily in nitric acid. The solution is blue, becoming green if diluted with water. Two specimens gave an atomic weight of 145·95. It is precipitated by caustic potash, ammonia and carbonate of soda; the green precipitate is soluble in all these reagents and giver blue solutions. Sulphuretted hydrogen gives, even in very acid solutions, a brown precipitate insoluble in sulphuret of ammonia. Borax, in the oxidizing flame, gives a yellowish green gloss, becoming blue in cooling. The blue color is shown in the reducing flame. It is easily reducible with carbonate of soda, or upon carbon.—*Comptes Rendus.* C.

Gum Arabic Solution.—The adhesiveness and durability of a solution of 100 parts gum arabic in 250 parts water may be increased by adding 2 parts of sulphate of alumina.—*Polytech. Notizbl.* C.

Artificial Quartz Crystals.—MM. Friedel and Sarrazim have obtained quartz crystals by the action of hydrochloric acid upon gelatinous silica in closed vessels, at a temperature of 350° (662°F.).—*Soc. Chim. de Paris.* C.

Defoy's Electric Bit.—The reins enclose a small conducting wire, extending from the bit to a small electro-magnet. By turning the crank of the electro-magnet, a slight current is sent to the horse's mouth, causing such surprise that he stands immovable, and is easily tamed by caresses. The current is not strong enough to give a shock or to stupefy the animal.—*Les Mondes.* C.

Heat of the Electric Arc.—Prof. Rosetti, of the University of Padua, has measured the temperatures of the electric arc and of the carbon points. With 80 Bunsen elements he found for the negative 2400° (4352°F.), for the positive pole 2870° (5198°F.), and for the arc 359° (6332°F.). These temperatures decrease with an increase in the number of elements employed.—*Soc. Franc. de. Phys.* C.

Electric Light in Persia.—Fabius Boital recently exhibited the Jablochkoff light before the Shah of Persia. When the machine was started, the Shah turned on the light by a gentle pressure, and all the bystanders gave a shout of admiration, which was repeated when they found that the street lights were kindled at the same instant. M. Boital has been engaged to introduce a large supply of electrical apparatus, to build extensive gas-works, to erect a series of dwellings of a plan and architecture hitherto unknown in Teheran, and to construct an Industrial Palace.—*Les Mondes.* C.

Paper Window-shutters.—William Hipkins, of Belair, Ohio, has taken out a patent for window-shutters in which pasteboard is substituted for wood. The slats and panels can be covered with colored or stamped paper, so as to imitate any desired kind or pattern of wood. The inventor claims as advantages for such shutters that they are lighter and cheaper than wood, that they do not warp or split, that they can be easily fitted to new positions, that they are susceptible of a great variety of patterns, and that they will contribute to an improvement in the appearance of cheap dwellings.—*Fortsch. der Zeit.* C.

Speaking Dictionary.—M. Lambrigot has invented a modification of Edison's phonographic matrices, by substituting stearine for the tin foil, and electrotyping the impressed surface. It has been suggested that these electrotypes, which can be made very cheaply, may render great service in the study of foreign languages, for they preserve indefinitely and repeat as often as may be desired words that are the most difficult to pronounce correctly. A true speaking dictionary might thus be made, an undertaking which the wildest fancy would not have dreamed of a few years ago.—*Le Nature.* C.

Electrolysis in Soda Manufacture.—M. Merle, the manufacturer of the chemical works of Merle & Co., has erected electrical machines, which are employed to eliminate, by means of electrolysis, the whole of the iron and other metals, such as lead and arsenic. The separation of these metals is effected very rapidly, in large quantities, at a comparatively small cost. The soda crystals which are obtained from the concentration of the leys are very white, and well adapted to the bleaching of fabrics previous to drying. The manufacture of soda crystals and caustic soda, in the south of France, is very difficult, on account of the high temperature, which makes the mother liquors too rich in carbonate of soda. C.

Distribution of Power by Electricity.—Numerous experiments have lately been made in Paris on the transmission of power by means of two Gramme machines, one producing an electric current by mechanical action, the other operating inversely, and reconstituting a portion of the labor which was originally expended. In order to make careful measurements, M. Tresca estimated some of the experiments with a Gramme machine making 1200 revolutions per minute. The current was transmitted, by copper wires, to carts at different distances, two Gramme machines being placed on the carts and acting on a windlass, which pushed a double Brabant plough so as to make a furrow 220 metres (240·6 yds.) long. The velocity of the plough, when the circuit of the current was 800 metres (874·91 yds.), was 88 centimetres (34·65 in.) per second, the shaft making 1123 turns per minute; when the circuit was increased to 1300 metres (1421·72 yds.), the velocity was increased to 70 centimetres (27·56 in.) and the revolutions of the shaft to 890. The effective work was estimated at three horse-power.—*Comptes Rendus.* C.

Book Notices.

FRICTION AND LUBRICATION. Prof. R. H. Thurston. 1 vol., 8vo, 212 pages. The Railroad Gazette, New York, 1879.

It will be hard to over-estimate the value of the experimental results given in this little work to the mechanical engineer.

Heretofore the results given in published works have in many points been incomplete, if not grossly erroneous.

While Prof. Thurston's results will not carry with them to the minds of others such positive convictions as seem to have arisen in his own, nor will his deductions always be applicable to the ordinary cases occurring in mechanism without the introduction of a large factor of safety, still, thanks to his labors, the practitioners of engineering are now in possession of a mass of data such as will serve as a guide in a field hitherto almost unknown.

A careful study of the tables shows the overpowering influence which the temperature of the journal has upon the coefficient of friction, and the necessity which exists of keeping journals at some fixed temperature which has been found most economical for the lubricant used, or which does not affect injuriously the working of the machine under consideration.

This constant temperature is an unavoidable necessity in actual practice, and must be attained; and on this point, upon which Prof. Thurston does not seem to have laid sufficient stress, we have most valuable information in the experiments of Mr. A. H. Van Cleve, given on page 155.

This table clearly shows that where the lubricant is supplied at a uniform rate and an approximately constant temperature of journal is held, that the work or heating which a journal will withstand at varying speeds and pressure closely approximates to a uniform quantity, and therefore that in practice the length of the journal is the only factor to be considered in order to prevent heating, the diameter of the journal being afterward so established as to prevent undue pressure or abrasion.

On page 56 Prof. Thurston gives, without stating any reason when he states the fact, the following formula for the length of journal bearing

$$l = \frac{P\ V}{60000d}$$

in which l = the length of the journal in inches, P = the load in lbs., V = the velocity in feet per minute, and d = the diameter of the journal in inches.

It is difficult to make use of this formula, because it is necessary to assume a value for d.

It is comparatively easy to simplify this formula so as to avoid the necessity of assuming a value for d. Taking for example the first experiment of Van Cleve, on page 155, we find the pressure per square inch to be 167 lbs., and the velocity of the rubbing surfaces to be 196·35 feet per minute. From the table, page 185, we find, with sufficient approximation *for the most favorable conditions possible*, that the coefficient of friction is one-half of one per cent., and therefore that the work per square inch of area is

$$\frac{167 \times 196{\cdot}35}{200} \text{ ft. lbs.} = 163{\cdot}62 \text{ ft. lbs.} = 1963{\cdot} \text{ inch lbs.}$$

Now, letting $N =$ the number of revolutions per minute, and $f =$ the coefficient of friction, we have for the work of friction per square inch of area,

$$f \frac{P}{l\,d} \times \pi\, d\, N = \pi f \frac{P' N}{l}$$

If we equate this with the work just derived from experiment, we have

$$l = \frac{\pi f}{1963} P' N$$

P' and N are always known, and f may be determined from inspection of the tables of experiments and a sufficient increase be made to cover contingencies.

Many times when lines of shafting are taken down the journals will be found to have worn smooth in only a small part of their length, and in the case of crank pins and journal bearings, their heating, where there is the least lack of rigidity or the engine is out of line, defies all precautions.

The wear and tear of mechanism will not permit the use of the coefficients given in the tables, in ordinary practice, without large increase.

Conclusion 11, page 211. "The only method of learning the true value of a lubricant is to place it under test," is in brief the result of the many and varied experiments set forth.

The elaborate descriptions of testing machines and methods of testing oils are of great interest to all engineers and intelligent mechanics.

The work is well worth the careful reading of every one interested in the mechanic arts. It is much to be regretted that the faith of the reader in the accuracy of the tables is shaken by the slovenly proof-reading, discovered where errors are easily detected. M.

COMPUTATION OF TIME AND CHANGES OF STYLE IN THE CALENDAR. Addressed to Students of History and Genealogy. By Spencer Bonsall. Reprinted from the "Pennsylvania Magazine of History and Biography," Vols. II, III.

In this pamphlet the author has collected a mass of valuable information respecting the Julian and Gregorian Calendars, the Calendar of the Society of Friends, the Ecclesiastical and Historical Years, the Calendar of the French Republic from 1792 to 1806, and the dates at which the new style was adopted in the principal countries of Europe. The mistakes which are frequently made, even by literary men, when writing of past events; the fickle action of Roman pontiffs, who changed the year capriciously, so as to lengthen or shorten the period during which a magistrate remained in office; the details of the reformation introduced by Pope Gregory XIII; the rules for determining the day of the week for past or future events; the action of the Nicene Council in fixing the days on which Easter and other movable feasts should be celebrated; the frequent adherence to the old style in England, by making rents payable on the old quarter days, and many other items of interest have been collected with an industry and fidelity which deserve great commendation.

In preparing the work, the statements of the best authorities were collated, and information which was found scattered in various volumes was brought together in a condensed form. Many useful suggestions are given to students, and a brief appendix is added of notes on sundry calendars, by Alexander Wilcocks. The whole may be read with pleasure by all who are merely in search of general information, and special students of history or genealogy will probably find in its pages every important fact in relation to the subject which is accessible anywhere. C.

SANITARY ENGINEERING; a Guide to the Construction of Works of Sewerage and House Drainage. With Tables for Facilitating the Calculations of the Engineer. By Baldwin Latham, C. E. New York: G. H. Frost, 1877. 4to, pp. 72.

The importance of good sewerage is being more and more recognized, and it is therefore gratifying that the above work, which is the only complete and systematic treatise on the subject, has been republished and is sold at a price which makes it accessible to all who are interested in the matter. Although specially adapted to English prac-

tice, it contains the guiding principles which can readily be adapted to local conditions and peculiarities.

Beginning with a general inquiry into the character of the district to be sewered, viz., the geological, physical and topographical features, the rainfall, water supply and population, the author shows their respective bearings on the proper design of the works. He then enters into the discussion of the course, size and grade of sewers necessary to make them self-cleaning and otherwise efficient. The merits of the various sectional forms are carefully considered, together with the relative advantages of the materials used in building them. We are then informed of the importance of a proper mode of making the junctions with sewers, of providing flushing arrangements, and due space is given to the subjects of ventilation and trapping. The closing chapters are on house drainage.

The American publisher has appended a very full set of specifications for the construction of a large sewer in New York city, and a translation of the very valuable pamphlet, "The Planning and Building of Sewers," by J. Chailly, both of which greatly add in worth to the above work. The text is fully illustrated with 19 large quarto plates. H.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 17th, 1879.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 174 members and 66 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 17 persons were elected members of the Institute at their last meeting.

The Secretary reported the following donations to the Library:

Reports and Awards. Internat'l Exhibition, 1876. Philadelphia. J. B. Lippincott & Co. 1878.

Report of the Director General. Intern. Exhibition, 1876. Philadelphia. J. B. Lippincott & Co. 1879.

Grounds and Buildings of Centennial Exhibition. Philada., 1876.

Reports of the President, Secretary and Executive Committee Centennial Exhibition. Philada. J. B. Lippincott & Co. 1879.

Appendix to the Reports of the United States Centennial Commission and Board of Finance. Philada. J. B. Lippincott & Co. 1879.
From the United States Centennial Commission.

American Engineering. Illustrated. By G. Weissenborn, N. Y. 2 vols. From Fred'k Graff.

Report of Twelfth Annual Convention of the American Railway Master Mechanics' Association. 1879. From the Association.

American Engineering, as illustrated by the Amer. Society of Civil Engineers at the Paris Exposition of 1878.
From John Bogart, New York.

Report of Prof. S. F. Baird, Secretary of the Smithsonian Institution, for 1878. From the Institution.

Bulletin of the U. S. Geol. and Geog. Survey of the Territories. Vol. V, No. 2. Washington. 1879.
From the Dept. of the Interior.

Annales de Chimie et de Physique, par MM. Chevreul, Dumas, etc. 3d Ser. Vols. 49—51 in one vol.
From Mr. Henry Pemberton, Philadelphia.

Second Geological Survey of Pennsylvania. Reports M2, P and V.
From the Board of Commissioners of the Survey, Harrisburg.

Annual Report of the Council of the City of Manchester on the Working of the Public Free Libraries. 1878–'79.
From the Council.

U. S. Geol. and Geog. Survey of Colorado and adjacent Territory. 1876. Tenth Report. by F. V. Hayden.
Report on the Geology of the Henry Mountains. By G. R. Gilbert. Washington. 1877.
Report on the Lands of the Arid Region of the United States. With Maps. By J. W. Powell.
From the Interior Department, Washington.

Geological Survey of Canada. Report of Progress from its Commencement to 1863. Atlas of Maps and Sections. Montreal. 1865.
Report of Progress for 1877–78. With Maps. Montreal, 1879.
Notes on the Gold of Eastern Canada. Montreal. 1864.
Remarks on the Mining Region of Lake Superior. By W. E. Logan. Montreal. 1847.
Petroleum. Its Geological Relations in Gaspé. Quebec. 1865.
Canada. A Geographical, Agricultural and Mineralogical Sketch. Quebec. 1865.
Report on Fossil Plants. By J. W. Dawson. Montreal. 1871 and 1873.

New Species of Lower Silurian Fossils. By E. Billings. Montreal. 1861.

Lawrenthian Limestones of North America. By T. S. Hunt.

Esquisse Geologique du Canada. Paris. 1867.

Descriptive Catalogue of a Collection of the Economic Minerals of Canada. 1862.

Report of Dr. T. S. Hunt on the Gold Region of Nova Scotia. Ottawa. 1868.

Reports of Mr. A. Michel and Dr. T. S. Hunt on the Gold Region of Canada. 1866.

Catalogue des Mineraux, Roches, etc., du Canada. Par B. J. Harrington and A. C. Sellwyn. London. 1878.

Catalogue of Silurian Fossils. By E. Billings. Montreal.

Descriptive Catalogue of a Collection of the Economic Minerals of Canada; and Notes. Montreal.

Palæozoic Fossils. Vol. 1, 1861–'65. Vol. 2, Pt. 1, 1874. Montreal.

Figures and Descriptions of Canadian Organic Remains. Decades 1—4. Montreal. From the Geological Survey of Ganada.

Specifications and Drawings of Patents. July, 1879.
From U. S. Patent Office.

Fifty-Ninth Annual Report of the Managers of the Apprentices' Library Co. Philadelphia. From the Company.

J. Snowden Bell, Esq., read a paper on "Locomotive Spark Arresters," and some remarks were made on the subject by Mr. John W. Nystrom.

Mr. George Richards read a paper on "Standard Sizes in Cylindrical Fitting," which was discussed by Mr. William Sellers and other members.

Mr. Richard S. Rhodes gave some account of his "Audiphone," and several forms of the instrument were exhibited.

Dr. J. Cheston Morris read a short paper on "Improved Methods of Milk Shipment."

The Secretary's Report inclosed an account of the "Victor Automatic Fire Extinguisher," invented by Mr. E. Leonard; Janesville Safety Lamps; Hydro-Carbon Heating Apparatus; Edison's New Phonograph; Wilson's Touroscope; Cabinet Orguinette of Mr. Wm. Blasius; Tyson's Improved Motor for Sewing Machines, etc.; Lester's Milk Cans; Warren Milk Bottles; Robertson's Horse Shoe; Kuhnle's Patent Stair-rod Holder; and Gelatine Duplicating Sheets.